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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RADIATION AND NUCLEAR MATERIALS SUBCOMMITTEE

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WEDNESDAY, MARCH 2, 2016

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear
Regulatory Commission, Two White Flint North, Room
T2B1, 11545 Rockville Pike, at 8:31 a.m., Dennis C.
Bley, Chairman, presiding.

COMMITTEE MEMBERS:

DENNIS C. BLEY, Chairman

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

DANA A. POWERS, Member

HAROLD B. RAY, Member

PETER RICCARDELLA, Member-at-Large

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

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ACRS CONSULTANT:

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER L. BROWN

ALSO PRESENT:

HAROLD ADKINS, PNNL

JOE BOROWSKY, NMSS

JIMMY CHANG, NMSS

JAMES FORT, PNNL

DONNA GILMORE, Public Participant*

DAVE HOFFMAN, Public Participant*

MERAJ KAHIMI, NMSS

WALT KIRCHNER, Public Participant

MARK LOMBARD, NMMS

JASON PIOTTER, NMMS

ANDREA D. VALENTIN, Executive Director, ACRS

*Present via telephone

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Adjourn

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

(8:31 a.m.)

CHAIRMAN BLEY: Good morning. The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Radiation Protection and Nuclear Materials.

I am Dennis Bley, Chairman of this meeting. Members in attendance are Harold Ray, Dana Powers, John Stetkar, Dick Skillman, Pete Riccardella, and Ron Ballinger, and our consultant is with us, Steve Schultz.

The purpose of this meeting is to receive information briefing on Staff's development of Draft NUREG/CR-7209, a Compendium of Spent Fuel Transportation Package Response Analyses to Severe Fire Accident Scenarios. The Subcommittee will hear presentations by and hold discussions with representatives of the NMSS Staff.

A little history; back almost forget, it was 15 years ago or so there was a National Academy study that looked at transportation and kind of thought everything was okay except they said the case hadn't been made for fully engulfing fires. And this work, I think -- it started before

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1 that, but it continued after that with a lot of
2 research at NIST we'll hear about.

3 The rules for participation in today's
4 meeting have been announced as part of the notice
5 of this meeting previously published in the Federal
6 Register on February 18th, 2016. A transcript of
7 the meeting is being kept and will be made
8 available as stated in the Federal Register notice.

9 It is requested that speakers first
10 identify themselves and speak with sufficient
11 clarity and volume so that they may be readily
12 heard. We ask at this time that you silence your
13 phones and other electronic devices. Although we
14 have -- I don't think I did mine yet. Although we
15 have a bridge line open, it's currently in the
16 listen-in mode only during the meeting and no one
17 from the public has requested time to make any oral
18 statement or written statements.

19 Did I skip a -- yes, I think I did.
20 Chris Brown is the Designated Federal Official for
21 this meeting. Sorry, Chris.

22 We will open the phone line late in the
23 meeting to allow public comment.

24 We'll now proceed with the meeting, and
25 I call upon Mark Lombard, Director of the Division

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1 of Spent Fuel Management, NMSS, to begin. Mark.

2 MR. LOMBARD: Thank you, Dr. Bley,
3 appreciate it.

4 As we've discussed with you all and
5 with the Commission, as well, there's a lot of
6 moving parts to the spent fuel puzzle, and the
7 discussion today is Draft NUREG/CR-7209 that we'll
8 be presenting is really an important part of that
9 puzzle.

10 We've issued the Draft NUREG for public
11 comment on January 25th, and encourage your
12 comments, as well. The comment period closes on
13 March 28th. It really contains a summary of four
14 case studies of severe fire accident scenarios and
15 refers to extensive analyses that we have performed
16 over the past 14 years, as you've pointed out.

17 It complements work that we've done on
18 spent fuel transportation risk assessment. We've
19 reissued that report about a year and a half ago,
20 and it complements, again, the information we have
21 in the SFTRA, S-F-T-R-A, report, shows that the
22 risk of spent fuel transportation is really less
23 than that that's posed by background radiation, and
24 I think we found through the fire studies the risk
25 of engulfing fires to spent fuel transportation

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1 safety and security is low, so we'll go through
2 some of the details today.

3 I'd like to introduce folks at the
4 table. From the Division of Spent Fuel Management
5 is Jimmy Chang and Joe Borowsky, who are our main
6 compilers of this information that went into the
7 Draft NUREG, and also from PNNL, the Pacific
8 Northwest National Laboratory are Harold Adkins and
9 James, I'm sorry, James Fort. I almost forgot your
10 last name, James Fort. PNNL provides us really good
11 support here in the thermal areas and other areas,
12 as well. But primarily in the thermal areas, they
13 really have helped us out on licensing support, but
14 also case studies such as what you'll find in the
15 spent fuel -- I'm sorry, the Fire Compendium. So
16 without further ado, I'll turn it over to our folks
17 and start the presentation.

18 CHAIRMAN BLEY: Just before you start, I
19 should announce that Member Charles Brown has
20 joined the Committee at the table. Thanks, Charlie.
21 Go ahead.

22 MR. CHANG: Okay. Good morning,
23 Committee Members. I'm Jimmy Chang.

24 As you see the title, Compendium of
25 Spent Fuel Transportation Package to the Severe

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1 Fire Response Analysis to severe fire accident
2 scenario. I will talk about accidents in low way
3 and my colleague, Joe Borowsky, will talk about the
4 fire accident and the low rate.

5 The talk will cover the motivation of
6 severe fire study regulation, fire scenario and
7 consequence, and then conclusion. The first part
8 talk about Part 71. Part 71 has three main
9 sections. The first one, how to approve the design
10 of a package. The second part, how to test your
11 package.

12 We have five tests, drop test, crush
13 test, puncture test, fire test, and the last one,
14 water emersion test. In the meantime, Part 71 also
15 provide operating control and procedure, so this
16 amends main section in Part 71.

17 I want to go back the history about
18 this research, this study. The first NRC light, the
19 Sandia light, the fire may exceed the condition
20 defined in the Part 71 regulation. In Part 71
21 define the fire temperature is 1475 Fahrenheit,
22 that's 800 Celsius for 13 minute. However, based on
23 a accident in railway in Baltimore in 2001, NRC did
24 the research and later on NIST, National Academy of
25 Science, they build a database and the research and

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1 analysis, and they commend in their 2006 report
2 that you see in the slide from going the distance,
3 recommend additional analysis in the fire accident.
4 So, at that time NRC continue another three
5 accident in the low rate; Caldecott Tunnel fire,
6 Newhall Pass Tunnel Fire, and MacArthur Maze fire.
7 Joe will go through more detail in those three low
8 rate accident.

9 CHAIRMAN BLEY: Your reports on those
10 three are now -- all of them are available
11 publicly, I notice.

12 MR. CHANG: Yes. Again, we talk about
13 the topic. NRC has conducted the research in type
14 and quantity of view available in actual fire, and
15 the possible range of temperature in ideal
16 condition and the real condition, and how long the
17 fire could be in an accident, and the effect on the
18 package from small sites to the large site from low
19 decay heat to high decay heat. And it was a
20 different design configuration. And also look into
21 the behavior of important to several components
22 during the fire.

23 When I talk about ITS important to
24 focus on the field creating containment seal,
25 neutron seal, and the gamma shield. In the

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1 meantime, we also look into the additional action,
2 any action we can take, we could have to minimize
3 or exclude the accident. Next slide.

4 So NRC work with PNNL, Pacific
5 Northwest National Laboratory. We have our two
6 friends over here, and NIST, and CNWRA, Center for
7 the Nuclear Waste Regulatory Analysis, and we
8 worked together, and we published a lot of report,
9 like the first one, the railcar component to
10 tunnel fire. And we had a database for railway
11 accident and roadway accident. And like number four
12 we do get a structured response to the fire. And
13 number five, we look at the performance of
14 containment all the material. And for the last
15 four, Baltimore Tunnel fire, Caldecott, MacArthur
16 Maze, and Newhall Pass we also look at the fire
17 effect on those package. However, I need to
18 emphasize not those four fires, Baltimore,
19 Caldecott, MacArthur Maze, and Newhall Pass really
20 involved radioactive material. No they are not the
21 radioactive material spent fuel, either they still
22 want to look at the impact for the spent fuel on
23 the roadway or the highway, how -- what could
24 happen, and we want to study that condition.

25 So now let me -- let's look at railway

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1 accident. When we talk about a severe fire there
2 are two criterion. The first one, the rail car must
3 fully be engulfed in the fire. We had the finishing
4 what would be the engulfing fire and that
5 information in the compendium. And the second one,
6 the principal source of fuel must come from another
7 vehicle.

8 People may question is that the only
9 source for the fuel, is that possible? We may
10 neglect other source of the fuel. My answer is no,
11 because based on the regulation requirement of --
12 we do ask for the railway -- a railway, we only
13 allow the spent fuel radioactive material cask in
14 the train without in the one rail car without other
15 freight. So, therefore, the fuel source must come
16 from another rail car because in this rail car we
17 only have spent fuel cask without other freight.
18 And that is the same situation for the roadway
19 condition, one track only carrying spent fuel cask.
20 Therefore, this will be --

21 CHAIRMAN BLEY: Jimmy, is that by NRC
22 policy? Is that by law, is that by railroad
23 agreement? What assures us that there are -- that
24 the trains are dedicated?

25 MR. CHANG: Well, I think DOT regulation

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1 has that requirement.

2 MR. BOROWSKY: Yes. I mean, I just want
3 to stress that it's -- what Jimmy had said was that
4 the package is on a single rail car, and there
5 can't be any other combustible material on that
6 rail car. So in order to --

7 CHAIRMAN BLEY: Just on that one rail
8 car, or is the two adjacent to it, as well?

9 MR. BOROWSKY: Well, if there is any
10 type of combustible material, if there were to be,
11 they would have to be a buffer car --

12 CHAIRMAN BLEY: Okay.

13 MR. BOROWSKY: -- between them.

14 CHAIRMAN BLEY: And that's DOT
15 regulations.

16 MR. BOROWSKY: That's a DOT regulation.
17 Correct.

18 CHAIRMAN BLEY: It is regulation,
19 though.

20 MR. BOROWSKY: Right.

21 CHAIRMAN BLEY: Okay.

22 MR. CHANG: Yes.

23 CHAIRMAN BLEY: There could be on the
24 rest of the train, but it's just not the car the
25 cask is on, or the two next to it.

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1 MR. BOROWSKY: That's correct. It's
2 possible.

3 CHAIRMAN BLEY: Yes, okay.

4 MR. CHANG: And that is DOT regulation
5 49173.

6 Again, I focused on the railway
7 accident. Now we want to see the potential for how
8 -- for high temperature and longer duration fire in
9 the railway. We look at five factor, railway
10 material, fuel formation, orbing effect, space
11 distribution, and the oxygen supply. And we want to
12 know which tear could be most severe in open field
13 or in tunnel, and we compare -- first we look at
14 the rail bed material instead of the polar
15 substrate in the open field. Most of the tunnel we
16 had rock, concrete, and pavement for the tunnel,
17 and that's not easy to form for the different form
18 of liquid to fully engulf the package.

19 And the second orbing effect with the
20 fire in the tunnel, the fire will raise the
21 temperature on the tunnel wall, ceiling, and the
22 ground. And even the fire is extinguish the heat
23 will continue transport from the wall, ceiling,
24 ground into the package like a secondary heat
25 input, so that is the condition with spent high

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1 temperature in packaging in tunnel. And then
2 because the limited space in the tunnel it's more
3 difficult for emergency people to cool down the
4 tank to extinguish the fire. So if we look at the
5 factor from one to four in favor, that means we
6 will have the fire temperature in the tunnel.

7 The last one, the oxygen that it could
8 be more favorable to the open field fire. However,
9 we found out the hotter temperature and the long
10 duration fire is in the tunnel, it's tunnel fire.
11 That's why we think about that in the case we look
12 into in this study in this presentation.

13 CHAIRMAN BLEY: Now before you go on, in
14 some tunnels, I would think in longer tunnels, they
15 probably have ventilation shafts. Is that true, so
16 that you would get some circulation?

17 MR. CHANG: We do both study without
18 ventilation and with ventilation. We do both.

19 CHAIRMAN BLEY: Okay.

20 MR. CHANG: And we pick up identical
21 details for Baltimore fire. The fire last about
22 three hours, three hour in an actual situation.
23 However, in some analysis we assume seven hour
24 based on full ventilation, and we look at that case
25 and think about conservative, so we do the -- we

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1 did consider that situation.

2 CHAIRMAN BLEY: Okay.

3 MEMBER BALLINGER: I have another
4 question. I have some experience with the tunnel in
5 Boston where they did a poor job of attaching the
6 ceiling tiles which weigh several tons each. And
7 one of them came off and fell on a car and killed
8 somebody because there's an epoxy ceiling thing
9 where the studs went in. In these tunnels, is it --
10 has anybody looked at the fact that the ceiling
11 tiles are not really -- they're not the kind of
12 tiles that are in this room. They're these cement
13 tiles that divide the air flow space from the
14 personal space, the possibility of those things
15 coming down on top of the package and complicating
16 life?

17 MR. BOROWSKY: In one of our analyses,
18 was the MacArthur Maze scenario. This was a roadway
19 accident. It's kind of an analogy to what you're
20 saying. In that situation there was a roadway and
21 an overpass, and because of the high temperatures
22 from the fire what happened is basically it
23 weakened the overpass spans and they came down and
24 impacted the package. And I'll present the results
25 in a little bit, but basically the strain on the

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1 package was very minimal.

2 MEMBER BALLINGER: I'm concerned about
3 people getting to it, if all these -- if the
4 ceiling basically comes down in that part of the
5 tunnel, access, like you were talking about, access
6 for medical, for other people.

7 MEMBER SKILLMAN: Jimmy, I'd like to ask
8 a question, please. What is the degree of buy-in of
9 the codes that have been used for these analyses?
10 There was a time when the NRC only used the scale
11 codes, NMSS only used the scale series of codes for
12 these analyses; although, there were other very
13 elegant and widely used industry codes that could
14 have been used. So for the requirements of the Part
15 71 they kind of back into 49 CFR which are the
16 transportation regulations, what codes are
17 acceptable and what is the standard by which you
18 are using those codes for acceptability?

19 MR. CHANG: We used the computer code,
20 COBRA-SFS. That computer code -- we used two code.
21 I will give more detail in the slide, next one, but
22 basically we use two type of computer code. The
23 first one we call FDS, Fire Dynamics Simulator.
24 That was developed by the NIST. We use that one to
25 predict the fire condition in the tunnel. And then

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1 we use those output as input for the summer
2 structure code, either COBRA-SFS. That was
3 developed by the PNNL and the ANSYS to see the
4 summer response in the package. However, let me
5 give you more detail.

6 MEMBER SKILLMAN: Let me pull the thread
7 a little further and you'll see the direction of my
8 question. Are the cask manufacturers using those
9 same codes, and are they aligned with you in use of
10 those codes?

11 MR. CHANG: The kind used, I mean the
12 packaging manufacturer used the -- many type of
13 computer code ANSYS in COBRA-SFS. We have the NUREG
14 as the guidance to tell the user or the
15 manufacturer what type of code we approve. We did
16 the tunnel review and the provocation, so the cask
17 user or manufacturer need to use the computer code
18 we approve.

19 MR. ADKINS: Another thing I'd like to
20 add. This is Harold Adkins from PNNL. Dr. Skillman,
21 very good question. So either indirectly or
22 directly those codes that the applicants apply are
23 evaluated based on the results that they produce
24 and the analytical methodology that they employ by
25 virtue of the fact that either our lab or other

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1 labs that support the NRC will apply those codes
2 that are more often validated heavily. In fact, to
3 speak to COBRA-SFS, DOE -- that was a code that was
4 developed by DOE. It was used to perform 78 -- more
5 than 78 blind pretest predictions on standard NCT,
6 as well as NCS storage evaluations, and also some
7 fire benchmarks that were performed, actual fires
8 for the calorimeter study at Sandia.

9 As far as the structural codes that
10 were employed on some of these particular
11 applications like the MacArthur Maze that Joe
12 Borowsky spoke of, there's been a lot of validation
13 studies and some validation history associated with
14 that code, as well, so I would think in the same
15 light they would have the same pedigrees like a
16 scale code. In fact, COBRA-SFS was reviewed by NRC
17 for DOE, so they were hired to review the outcome
18 of that code and the particular details associated
19 with that, and how it benchmarked to perform its
20 validation against those blind pretest predictions
21 in Idaho, and it was found to yield very good
22 results. And that's exactly why the NRC cut a
23 contract for independent evaluation to PNNL.

24 MEMBER SKILLMAN: Harold, thank you.

25 MR. ADKINS: You bet.

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1 MR. CHANG: So now I'm talking about --
2 I will talk about the Baltimore Tunnel fire
3 scenario. It was called Howard Street Tunnel fire,
4 like the tunnel located in the City of Baltimore.
5 In 2001 a train carrying flammable tripropylene
6 derailed and then the tenth car was punctured by
7 the braking vehicle containing them, so the
8 flammable liquid leaked and caused the fire.

9 The flammable liquid tripropylene has a
10 combustion heat almost identical to gasoline. In
11 Compendium we compared with different studies about
12 different type of flammable liquid, the combustible
13 and we found out that combustion heat of
14 tripropylene is at the higher end of the combustion
15 energy. So what we did in this case, we pick out a
16 high combustion flammable material and as you see
17 in the second bullet, the ignition was around three
18 hours estimated by the NTSB, National
19 Transportation Safety Board. However, we assume if
20 the tunnel was fully oxygenated the fire could last
21 seven hours with gas temperature about 2,000
22 Fahrenheit in the flame region. And at 66 feet
23 downstream the temperature was near 2,000
24 Fahrenheit. That's greater than 1475 Fahrenheit
25 defined in regulation, and seven hour, it was

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1 longer than the thirteen minutes again defined in
2 regulation, Part 71.

3 So now let me talk about --

4 MR. SCHULTZ: Jimmy, can you provide a
5 qualitative discussion of what has determined the
6 fully oxygenated case? As you describe that, it
7 could have lasted seven hours if it were fully
8 oxygenated. What factors went into that evaluation
9 versus the actual three-hour case?

10 MR. ADKINS: Yes, absolutely. This is
11 Harold Adkins from PNNL again. So backing up that
12 slide, there were a couple of factors that were
13 taken into account, one of which was when this
14 accident occurred the only thing that NIST could
15 surmise -- and again, you know, based on one of the
16 questions that was asked previously. This is a code
17 that's heavily validated, the FDS code where
18 they've validated its fire consumption rates and
19 heat output based on a number of different fires,
20 Runehamar fire and a couple of others that I'm not
21 recalling at this current moment. So anyway, they
22 took this validated code and they couldn't figure
23 out why the fire didn't burn more than three hours.

24 And then the other thing, too, is based
25 on the data that was collected that didn't

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1 corroborate, it indicated that the temperatures
2 were lower than what they would initially find
3 during the fires, so we set that as a high point
4 and said okay, you know, clearly there was fuel
5 that got absorbed into the rail bed and things of
6 that nature.

7 One of the other telling factors was
8 the ventilation fans were shut off on the Baltimore
9 Tunnel when the accident happened. So then what we
10 did is go back and evaluate if the whole fuel
11 inventory was available with full ventilation,
12 which is your fully oxygenated fire, evaluated that
13 temperature point and then did a best estimate of
14 what could actually occur based on how much fuel
15 loss could be assumed in the soil.

16 And one other key factor is when you
17 have tunnel fires, unless they have an insulated
18 construction with ceramic interface, like the tiles
19 are ceramic in nature, which is not a common
20 practice for construction in the United States,
21 more so overseas, you could end up with
22 substantially higher temperatures. So what we did
23 is, we maximized the temperature that was the
24 seven-hour peak temperature fire with the fuel
25 inventory that was available and then did a best

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1 estimate. And you see both of those numbers
2 reported in that particular report. Hopefully, that
3 answers your question.

4 MR. SCHULTZ: It does, and the
5 ventilation system just happened to be --

6 MR. ADKINS: Off.

7 MR. SCHULTZ: -- off?

8 MR. ADKINS: Yes. I think -- I can't
9 remember exactly the details, but I think it's
10 based on air stagnation because some of these
11 tunnels are slightly canted and they do ventilate,
12 passively ventilate very effectively. However,
13 versus something that's being buoyantly driven or
14 force fed, force feeding, you know, something with
15 oxygen is going to be the limiting case.

16 MR. SCHULTZ: Thank you.

17 MR. ADKINS: You bet.

18 MR. CHANG: Now we come to the computer
19 model. The first step we used our NIST perform --
20 we used the NIST code, FDA, Fire Dynamic
21 Simulator. We predict a fire condition in the
22 tunnel and then we used that as the bounding
23 condition to the summer code, COBRA-SFS that was
24 developed by the PNNL, and the ANSYS code. We do
25 use the summer code to verify the result to provide

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1 more confidence. And we had many conservative in
2 the FDS code when we use for analysis. The first we
3 assume fire fully oxygenated, and burns up to seven
4 hour to fully consume the fuel. The second one in
5 the model we have many -- we define the entire
6 computational domain as many subregion. Instead of
7 the local temperature distribution we pick out the
8 maximum temperature in each subregion and we use
9 the maximum temperature as the boundary condition
10 to the summer code. That's conservative.

11 MEMBER POWERS: Conservative with
12 respect to what?

13 MR. CHANG: Excuse me?

14 MEMBER POWERS: Conservative with
15 respect to what?

16 MR. ADKINS: I think the question you're
17 asking is, you know, based on a rudimentary
18 comparison how does that maximize your temperatures
19 that are the boundary condition inputs? So what
20 Jimmy is indicating is, when you have a whole
21 periphery around this, and you have pretty much a
22 steep gradient of temperatures around the periphery
23 of this tunnel that would influence the package,
24 what we did is broke that up in zones of what it
25 would see from a radiation interaction standpoint,

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1 and maximize that based on the output from the FDS
2 code, and took the highest temperatures --

3 MEMBER POWERS: Somehow that didn't
4 strike me as pertinent to the issue of
5 conservative. Conservative is something like heat
6 load on my radioactive material or something like
7 that.

8 MR. ADKINS: In essence it is, because
9 you're taking the peak temperature of the whole
10 zone instead of the distribution of the whole zone.

11 MEMBER POWERS: It is not obvious to me
12 that this maximizes the enthalpic input into my
13 package. I mean, suppose it's not fully oxygenated,
14 so it's -- the burning of the fire is dictated by
15 the oxygen supply so you have a longer time period
16 in which things burn, but it's not as hot. I get
17 more enthalpy -- I still get more enthalpy into my
18 package than I do with an intense but short fire.

19 MR. ADKINS: That's correct.

20 MEMBER POWERS: So I don't understand
21 what it's conservative with respect to.

22 MR. ADKINS: And I think one of the
23 things that we're trying to do is just hit
24 topically. I think in this particular case, we had
25 21 different boundary condition sets that we did to

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1 seek out -- and you raise a perfect point. When you
2 look at a -- especially a large-scale spent fuel
3 cask, it's got a huge thermal inertia, it's got an
4 internal decay heat load, so it can only absorb or
5 take on heat at a particular rate. So what we did
6 is perform 21 different studies to establish which
7 one elevated the peak temperatures imparted to the
8 fuel, the highest out of all of those cases with
9 the associated boundary conditions on how they
10 could exist realistically. Does that better answer
11 your question?

12 MEMBER POWERS: It still doesn't tell me
13 why you would write conservative assumptions up
14 there. Those are --

15 MR. ADKINS: Well, if you start from the
16 very reporting of the details of the accident and
17 the data that was gathered, there were only so many
18 materials that were compromised by the temperatures
19 that were incurred in the tunnel. We're going far
20 beyond that. We're taking all the fuel and figuring
21 out instead of allowing any of it to soak into the
22 substrate, or the soil, or the rail bed, we're --

23 MEMBER POWERS: Well, those might be
24 arguably conservative assumptions, none of them are
25 listed here.

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1 MR. ADKINS: Oh, that's an excellent
2 point. I think for brevity we didn't go into that
3 because the reports speak for themselves.

4 MEMBER POWERS: You're trying to snow
5 me.

6 MR. ADKINS: No. Am I -- maybe, Jim, am
7 I missing a point there?

8 MR. FORT: This is Jim Fort from PNNL.
9 And I think the basis of the conservative
10 assumptions were stated on this slide, is that
11 we're maximizing the heat input, the heat flux into
12 the cask. You bring up a good point that you could
13 look at a different scenario where you have --

14 MEMBER POWERS: I can put --

15 MR. FORT: -- a lot longer fire.

16 MEMBER POWERS: -- a billion watts onto
17 that cask for 39 nanoseconds and the cask won't
18 even think --

19 MR. ADKINS: You won't see it.

20 MEMBER POWERS: You won't see it.

21 MR. ADKINS: That's correct.

22 MEMBER POWERS: And that would look very
23 impressive. I'd put a billion watt source onto this
24 thing, but would not be a conservative assumption.

25 MR. ADKINS: Understood.

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1 MR. FORT: I think what we've done, and
2 you'll see over the course of the scenarios we look
3 at is, the one thing that's common in all of them
4 is that they're based on actual fires. So where we
5 could up with different conditions or imagine
6 different kinds of accidents that would --

7 MEMBER POWERS: Well, I think that's the
8 problem with the study. The study is that you
9 looked at fires that will never occur again.

10 MR. FORT: So these are very unlikely to
11 occur, but actually have occurred. And then we look
12 at conservative assumptions that maximize the
13 damage, potential damage to the cask.

14 MEMBER POWERS: Well, it would be nice
15 to see what those conservative assumptions are.
16 These aren't they.

17 MR. ADKINS: Yes. I think on the next
18 slide there's some more detail that's given, as we
19 get to it. So that was the basis in this case.
20 You'll see in some other cases where we looked at
21 the effects were more evident of a longer term, a
22 longer fire, and a longer cool down. This was
23 conservative for this test case, is the way we
24 judged it, by maximizing the heat input. The actual
25 accident that was observed was much shorter because

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1 it was oxygen-starved and they judged the fuel
2 content was lost to the subgrade, so we made the
3 selection of different conditions that would --

4 (Coughing.)

5 MR. ADKINS: I think the case we ran
6 would make it a more conservative or worst case.

7 MEMBER BALLINGER: I have some other
8 comments. Apart from being able to calibrate -- to
9 calculate a temperature to the nearest degree in
10 these analyses, I think somebody needs to correct
11 the numbers. But when you say conservatism, in
12 these cases there are some boundaries which you
13 cross, for example, the melting point of lead,
14 aluminum, steel, things like that, which if you
15 make a conservative assumption, you may cross one
16 of those boundaries. Where if you did a best
17 estimate, you wouldn't cross that boundary. Have
18 you considered that kind of calculation?

19 MR. ADKINS: Yes. Yes, we have.

20 MEMBER BALLINGER: Okay.

21 MR. ADKINS: And, actually, more of that
22 will become apparent as we go through some of the
23 latter slides. In fact, one of the packages that
24 was looked into -- and an excellent question, an
25 excellent point, is the NAC-LWT, which is a lead-

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1 lined cask. Right? Or the neutron shield is lead
2 and it's sandwiched by two stainless boundaries.
3 And one of the things that we had to do is look at
4 slump or reduction in shielding, as well as, you
5 know, how its conductivity would change over the
6 course of going through that process.

7 And then also, you know, one thing that
8 you can count on is latent heat effusion and how
9 that's going to change. It sucks up energy until it
10 finally melts. That was something that we didn't
11 have originally in the model. And the temperature
12 differences were marked, but they're, like you say,
13 you know, when you take apart and make that as a
14 conservative assumption that you don't have
15 melting, you're doing it with slightly higher
16 temperatures. That's correct.

17 MEMBER BALLINGER: Thank you.

18 MR. CHANG: Thank you.

19 CHAIRMAN BLEY: Yes. I want to follow-up
20 Dana's questions on the previous slide.

21 MR. ADKINS: Sure.

22 CHAIRMAN BLEY: Certainly, they were all
23 right. And you explained that you ran 20 some
24 cases.

25 MR. ADKINS: Yes.

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1 CHAIRMAN BLEY: Did it turn out when you
2 looked at all of those cases that the case that led
3 to maximum heat into the cask were the cases where
4 these three things were true, or did you just pick
5 these because these looked --

6
7 MR. ADKINS: No. There were quite a
8 sequence and this was some time ago, so I'm going
9 to try to recall all of those and then rely on Jim
10 maybe kicking me on a couple that I forgot. So
11 again, going back to the NIST code FDS, one of the
12 things that we noticed when it had a limited
13 ventilation is that you have the potential of, you
14 know, partially volatilizing the fuel, but mainly
15 making it evaporate and be even part of the cooling
16 of the fire where it doesn't get consumed because
17 there's a lack of oxygen. So one of the things,
18 obviously, is the ingredient to pump up the fire.
19 And then, you know, depending on pool size was
20 another factor. Depending on the pool size you only
21 get so much of a burn rate. And going back to Dr.
22 Powers' question, you know, so how is that
23 conservative? Well, considering the fact that these
24 packages, at least the larger packages have huge
25 thermal inertias, the point that was made is if the

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1 fire is instantaneous and you consume all the fuel
2 instantaneously, you will do very little to that
3 cask. So we played with -- played with, that's a
4 poor term, altered the -- and performed a
5 sensitivity study on the full fire square area and
6 burn rate to see what would be the worst effect.
7 And one of the things that comes out of this, and
8 it's easier to kind of establish, what the most
9 damning influence would be, it kind of heads
10 towards Dr. Powers' question, is when you cut off
11 the decay heat load's view to the outside world or
12 to a cooler ambient, that's really the most
13 damaging situation when you're looking at the
14 containment or the confinement characteristics of
15 the cladding of the fuel itself. It's not that the
16 fire insult is passing so much energy into the
17 package, so as soon as its view to the ambient
18 reaches cessation at least temporarily you end up
19 with temperatures and temperature excursions that
20 take place seven or eight hours after the fire.

21 So to get back to some of the
22 conclusions, or some of the assumptions that we
23 felt necessary to evaluate this as a worst case, we
24 performed all these sensitivity studies and tracked
25 the peak fuel cladding temperature as the

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1 determining factor. So how can we cut off that
2 particular entity's view to the ambient, and its
3 influence of being able to reduce or draw the decay
4 heat out, essentially? Hopefully, that answers your
5 question.

6 CHAIRMAN BLEY: It does a lot better
7 job. Yes, thanks.

8 MEMBER POWERS: Yes, it would suggest
9 don't put foam on these fires. That's what you
10 said, don't put foam on them.

11 MR. ADKINS: Don't put foam?

12 MEMBER POWERS: Don't use foam
13 firefighting equipment on these kinds of fires.

14 MR. ADKINS: I don't remember --

15 MR. FORT: Jim Fort, again. As an
16 insulating effect you were saying.

17 MEMBER POWERS: Yes. That's what you're
18 saying. I mean ---

19 (Simultaneous speaking.)

20 MEMBER POWERS: -- a fairly powerful
21 conclusion there to come out of it that didn't ---
22 somehow doesn't emerge.

23 MR. ADKINS: Well, one of the things
24 that we're going to discuss, too, here, when we had
25 to take a look at -- and this is one of the things

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1 that Joe will discuss, when we had to take a look
2 at the MacArthur Maze. Initially we thought, well,
3 you know, it is fully oxygenated because it's open,
4 but there's really only so many surfaces that are
5 going to heat up and have the radiation interaction
6 and elevated temperature to the package until you,
7 you know, go further having the rail structure fall
8 on the package and it's already elevated in
9 temperature, and it does exactly that, is insulate
10 it. Good point.

11 MR. CHANG: So the next one is the fire
12 boundary condition predict by the NIST FDS code. We
13 transfer data to the COBRA, the PNNL code, COBRA,
14 and the ANSYS, and then we predict the summer
15 response in the package getting the fire and post-
16 fire cool down. We did assumption the rail car and
17 package's supposed structure are neglected to
18 maximize the heat input into the package during the
19 fire. And then we use the first combustion in the
20 fire and natural combustion in the post-fire cool
21 down.

22 In fact, during the post-fire cool down
23 the temperatures could be still very high, and the
24 first combustion still exists. However, we assume
25 natural combustion to minimize the heat going out

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1 on the packaging. And then we put an intent limiter
2 and the neutron shield we retain a nominal property
3 field in the fire to maximize heat input the
4 package. And then back to the normal, and then
5 grade in the post-fire cool down to minimize the
6 heat out of the packaging.

7 All we want to is maximize the
8 component -- raise up the temperature of the
9 package component. We want to see how hot the
10 component could be. Are they going to abut the
11 temperature limit or still below the limit? So we
12 are able to justify what could be the worst
13 condition to those packaging component. And we used
14 a benchmark decay heat load in the package.

15 MEMBER SKILLMAN: Before changing, why
16 didn't you consider ignition of the impact limiter?
17 The impact limiters that I've been experienced with
18 are either redwood, cross-redwood, or they are high
19 density polyurethane. Both are combustible. Why
20 aren't those considered part of the heat load?
21 These are big. I mean, these --

22 MR. ADKINS: This is an excellent
23 question, so like all studies, kind of the system
24 of compromises, what we did is look at the industry
25 workhorses or ones that were going to become the

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1 industry workhorses, and of those particular
2 configurations, to make an example, in the
3 Baltimore Tunnel fire study, if the impact limiter
4 is exclusively made of seven different types of
5 oriented honeycombs, whether it be flex core,
6 cross-core, what have you. So, essentially, the
7 only thing it has to contribute to the fire other
8 than aluminum oxides and things of that nature is
9 literally the epoxy that joins the honeycomb before
10 it's constructed and actually put into service on
11 the HOLTEC HI-STAR 100. So what we did on that to
12 again provide conservatism is, we assumed that it
13 was in complete tact all the way through until it
14 hit its melting point, and then after it reached
15 its melting point, and this was, you know, over the
16 course of pinpointing very small volumes, we made
17 those radiation interfaces to draw more heat in
18 from the fire. And then after cessation of the fire
19 basically just capping that off as a thermal
20 insulator that was occupied by molten aluminum at
21 the bottom that had no access to the interface on
22 how it secures to the cask, and the rest of it was
23 merely a void that was occupied by gas with
24 decently low emissivities, so all you had was this
25 radiation gap that was an air thermal insulator on

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1 the end.

2 On the TN-68, it was wood, so that is a
3 consumable. And one of the things that we evaluated
4 is literally how much oxygen you would have to have
5 to stoke, if you will, and get that material to
6 burn. So we had a lot of problems with trying to
7 figure out how to capture that successfully without
8 breaching the impact limiter to provide an
9 interface where it would be -- what is it,
10 realistically or oxygenated enough to accommodate
11 the consumption of that wood. We ended up taking
12 the impact limiters completely off and just
13 exposing the ends of that cask to the fire itself
14 to maximize its insult because the thermal output
15 from the wood, you know, would be a lot less than
16 the actual fire to the impact limiter itself. Does
17 that --

18 MEMBER SKILLMAN: You're saying that the
19 heat input by the combustion of the wood is, in
20 fact, less than the heat input that would occur if
21 the impact limiter is not present.

22 MR. ADKINS: That's correct.

23 MEMBER SKILLMAN: Copy that. You sure?

24 MR. ADKINS: Yes.

25 MEMBER SKILLMAN: Thank you.

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1 MEMBER POWERS: I understand that you --
2 in the cases of aluminum honeycomb, you melt the
3 honeycomb?

4 MR. ADKINS: That's correct.

5 MEMBER POWERS: You take into account
6 the inner metallic reaction between molten aluminum
7 and the cask itself?

8 MR. ADKINS: The -- okay, the honeycomb
9 itself is sandwiched with very little capacity to
10 come out because of the fact that it's encapsulated
11 by stainless steel.

12 MEMBER POWERS: So you have a worse
13 inner metallic reaction.

14 MR. ADKINS: From the -- we didn't take
15 that into account, no. I guess I have to answer
16 that. But the one thing I will go on to comment, is
17 so you have an impact limiter that encapsulates
18 these seven types of honeycombs with septums that
19 are anywhere from a quarter-inch to a half-inch in
20 stainless that are then stood off of the cask and
21 bolt to the cask I think with Nitronic-60 bolts. So
22 you have an insulation gap that's anywhere from a
23 quarter to a half inch all the way around the
24 periphery from the impact limiter except for where
25 it engages and pulls into the bolts.

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1 MEMBER POWERS: Melt aluminum and drop
2 it on that stainless steel, it looks like somebody
3 went through with a cookie cutter, punch of bolts
4 in there, the stainless.

5 MR. ADKINS: Yes, I don't have
6 experience with that. I guess that's something that
7 we need to evaluate.

8 MR. SCHULTZ: With regard to that
9 bullet, this degradation of properties that are
10 seen in the post-fire cool down, could you describe
11 that in more detail, why that assumption, and what
12 is it, in particular, that's --

13 MR. ADKINS: So one of the things --

14 MR. SCHULTZ: -- degradation?

15 MR. ADKINS: So one of the things that
16 you can end up with depending on the amount of
17 oxygen available is on the outside if we're just
18 talking about emissivities, and you're talking
19 about the whole gamut. Right? Conductivities,
20 emissivities, everything. More often than not what
21 you'll end up with it sooting which raises the
22 emissivity of the package above .8, .9 to where
23 it's going to radiate and have a more effective
24 radiation interaction with the surrounding bodies
25 than it would normally if it didn't have that

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1 sooting. Okay? Because typical stainless steels can
2 range anywhere from .3 to .6, 16 if they have a lot
3 of surface roughness and are seasoned, if you will.
4 So those are raised to .9 during the fire, or
5 greater depending on the analysis and the ease of
6 using that tool, if you will, and then they're
7 reduced to a reasonable or conservative magnitude,
8 the emissivities would then be reduced or either be
9 representative. So that was one of the
10 sensitivities that we performed, as well, to look
11 at what a bounding calculation would be, and how
12 long that delays your peak fuel temperature hike
13 during the excursion after the fire is out.

14 MR. SCHULTZ: So it's a sensitivity
15 study --

16 MR. ADKINS: Exactly.

17 MR. SCHULTZ: -- in a conservative
18 direction.

19 MR. ADKINS: Exactly. With a lot of the
20 steels that are used in construction of spent fuel
21 casks, none of those hit melting points with the
22 exception of lead, so those are very easy. Then
23 it's just a matter of looking up reliable material
24 properties that come from Talupian and Sorg, and
25 making those track one for one with the local

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1 temperature and predictions associated with that,
2 you know, from a standpoint of being fully resolved
3 as an analytical model.

4 And then, you know, of course we talked
5 about the lead when you do go through a melting
6 temperature transition and what have you, whether
7 you take into account your latent heat effusion or
8 not, and how that influences the package and the
9 contents.

10 MR. SCHULTZ: Thank you.

11 MR. ADKINS: You bet.

12 MR. CHANG: Yes, in that case we have
13 seen many case work based on the regulation, the
14 package itself must be .8, that means more heat
15 would be into the package. However, that's still
16 maybe just .4 and we use .8. And then during the
17 post-fire it will be change the heat direction from
18 package to the ambient making this .8, too.
19 However, you go back and you check .4 to have less
20 heat going out so that it would be the case like
21 this.

22 MR. ADKINS: That's correct.
23 Sensitivity, again.

24 MR. CHANG: As I mentioned earlier, we
25 have four important to seventy component, fuel

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1 cladding, containment seal, gamma shield, and the
2 neutron shield. Now we had three different type of
3 packages, TN-68, that's a large with high decay
4 heat. HI-STAR 100, large package with decay heat
5 around 20 kilowatt. And then we have a small
6 packaging, NAC-LWT that's decay heat around 2.5
7 kilowatt. And based on the COBRA prediction we
8 found the peak cladding temperature, PCT, less than
9 1058 Fahrenheit, and that is the limit of fuel
10 cladding by NRC guidance. So all the fuel cladding
11 will be maintained integrity, will be in good
12 shape. And then we look at the peak temperature
13 yields used in the gamma shield because both TN-68
14 and the HI-STAR 100 use the steel as the neutron
15 shield material. As you know, the melting point of
16 steel is very high, so right now the condition we
17 are concerned. However, NAC-LWT used the lead as
18 the neutron -- use as the gamma shield material and
19 had the temperature greater than 622 Fahrenheit,
20 the melting point. That mean that lead as the gamma
21 shield material in NAC-LWT will be melted. However,
22 it still contain inside of steel cavity, so that
23 mean the lead could be melted, have expansion, and
24 then cool down, solidify again. And then we may
25 have the specs inside the cavity. They made a deal

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1 because we had the specs stay on top, it may reduce
2 the shielding effect. We did such investigation and
3 we found the maximum specs could be up to 5
4 percent, and that will cause the release going up.
5 However, still much, much below the limit in the
6 regulation.

7 And then for the neutron shield, in
8 fact, in regulation loss of neutron shield is a
9 design base assumption in the instant. In our
10 instant case for transportation packaging we assume
11 neutron shield will be lost and still below the
12 dose limit. So limiting the neutron shield is
13 required to me and no molten issue of transport.
14 Anyway, so even with loss of neutron shield in a
15 fire it still meet the dose limit requirement. Any
16 question?

17 MEMBER SKILLMAN: I think what you are
18 communicating is, you presume that the impact
19 limiter has reduced --

20 MR. CHANG: Oh, no.

21 MEMBER SKILLMAN: Let me finish, has
22 reduced the deceleration rate so that the lead has
23 not flowed in the cavity, so you do not have a
24 preexisting cavity void. And then when you proceed
25 to melt that lead the void that then exists, if

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1 there had been a void prior to then, still enables
2 the lead to perform its shielding function, and the
3 dose rates remain below the allowable
4 transportation dose rates. Is that what you're
5 saying?

6 MR. CHANG: Yes.

7 MR. ADKINS: Yes, for the most part. The
8 one thing that in the particular instance of the
9 NAC-LWT, we did not subject for the Baltimore
10 Tunnel fire the one that he's speaking to, to any
11 structural insult prior to lighting it on fire. It
12 was sitting on the conveyance. Otherwise, if it
13 were loaded -- adversely loaded to the extent that
14 it wouldn't be on the conveyance, it wouldn't be
15 subjected to such an extreme fire because then it
16 would be on the bottom of the rail bed or, you
17 know, elsewhere. Right? So we relied, like one of
18 the assumptions that Jimmy had, and then I'll
19 answer your question more perfectly, or more
20 completely.

21 What we did is basically assume that
22 this rail conveyance was not drawing any heat out
23 of the fire. It wasn't shrouding the cask from
24 receiving the full insult of the fire, and then
25 even more after it's exposed to that, you go

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1 through your lead melt. That expansion that would
2 take place, volumetric expansion due to the melting
3 would actually cause -- structurally load the
4 inner and outer shell such that it would slump and
5 produce the greatest gap on the top for shine in
6 the tunnel, and that was still evaluated to meet
7 the specific requirements in 10 CFR 71.73.

8 MEMBER SKILLMAN: Okay, thank you.

9 MR. ADKINS: You bet.

10 MEMBER SKILLMAN: Oh, one more question.

11 MR. ADKINS: Yes?

12 MEMBER SKILLMAN: You've identified
13 three casks here. What about the other casks? Are
14 these the only three casks carrying fuel?

15 MR. ADKINS: Yes.

16 MR. CHANG: Yes, but we think about
17 these three casks as representative.

18 MR. ADKINS: That's correct.

19 MR. CHANG: With different
20 configuration, different dimensional means, and
21 different heat load.

22 MR. ADKINS: Construction practices keep
23 capacity, so we go from large to small, as well,
24 different materials that are incorporated. You
25 know, you look at the big three vendors, cask

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1 vendors, and there's quite a bit of similarity
2 between the designs with the exception of wood
3 impact limiters, honeycomb impact limiters, web, EU
4 shielding which we evaluate on the MacArthur Maze,
5 I'm getting them confused. So we actually look at
6 DU cask in that particular case, and primarily due
7 to the fact that when we did the Baltimore Tunnel
8 fire studies, it only involved a small-scale cask
9 that has a lot less thermal inertia with one single
10 assembly. Well, GA-4, even though it hasn't -- they
11 haven't constructed one yet, I believe the CFC is
12 still current, and the intent was for it to
13 eventually see the light of day as being one of the
14 industry workhorses until we could start
15 transporting larger packages by rail and a
16 repository was identified. So what we did is we
17 tried to evaluate as many casks that were either
18 representative or were currently workhorse,
19 industry workhorses.

20 And to go on a little further is, when
21 you look at the big three who are the primary
22 manufacturers right now, HOLTEC I think dominates
23 55 percent of the industry within the United
24 States, and 78 outside. TN is the next runner up to
25 45 percent with their transport casks, so we picked

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1 the TN-68 which is a dual purpose cask. The HI-STAR
2 100 actually has a canister. We didn't know what
3 the net long-term effects were going to be with the
4 canisterized fuel, so we evaluated those two, and
5 then went for a small-scale cask, as well. That was
6 the intent behind the selection.

7 MEMBER SKILLMAN: Thank you.

8 MR. ADKINS: You bet.

9 MR. CHANG: And now we look at the last
10 components, containment seal. And we found out for
11 package TN-68 and NEC-1170 temperature are over the
12 limit. That mean there is a potential for
13 radioactive release from this to package. However,
14 because in all packages the temperature of the fuel
15 cladding is below the limit of 1058, so we don't
16 expect the limit for spent fuel particulate fission
17 gas and a particulate like a fine. The only release
18 could be cloud bullet number three, chuck liver are
19 known deposit. However, the activity is very low,
20 less than 82, less than 82. The 82 is a quantity
21 allow -- is the activity on the radioactive
22 material allowed in the Type A package. The 82 mean
23 it will not cause significant headache to the first
24 responder when they're near the packaging, so that
25 is very small amount of radiologic release.

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1 In the meantime, no loss in the gamma
2 shielding, and loss of the neutron shield would not
3 cause any dose consequence for all three packaging,
4 so we conclude the spent fuel packaging supplied by
5 the rail fire fuel integrity maintained and
6 radiation dose below limit. Any question?

7 MR. SCHULTZ: Is there a particular
8 quantification that is -- assumption that is used
9 with regard to the CRUD release?

10 MR. ADKINS: Yes. So one of the things
11 that we had to look at here is, when we evaluated
12 the cladding peak temperatures they weren't in
13 excess of what is currently accepted by the NRC as
14 kind of a vulnerability temperature where you would
15 actually get cladding breach. So the next thing
16 that we had to take a look at is what might be
17 available for dispersible inventory on the outside
18 of the cladding. Right?

19 MR. SCHULTZ: Understood.

20 MR. ADKINS: Yes. And then in this
21 particular calc, one of the conservatisms we
22 weighed in or incorporated was taking the inventory
23 of CRUD and assuming that it was available, the
24 full inventory instead of having like particulate
25 scale off and spall and then, you know, drop to the

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1 inside of the interior and not be available for
2 further dispersal, which would typically happen. So
3 we assumed that the CRUD inventory itself was
4 available to the public and dispersible, readily
5 dispersible, and that's what the AT number is
6 based on.

7 MR. SCHULTZ: Full inventory.

8 MR. ADKINS: Yes.

9 MR. SCHULTZ: Thank you.

10 MR. FORT: Let me just add. This is Jim
11 Fort, again. I think we used cobalt-60 as the basis
12 for --

13 MR. ADKINS: That's correct.

14 MR. FORT: That was the only additional.

15 MR. ADKINS: I forgot to mention that.

16 CHAIRMAN BLEY: I kind of missed that,
17 didn't look closely. Did you look at CRUD buildup
18 as we used to have because we're going to ship a
19 lot of old fuel first?

20 MR. ADKINS: Yes, that's right. And that
21 was exactly what was weighed into it, per the NRC's
22 recommendations over what should be anticipated for
23 the types of fuels. The other thing I forgot to
24 mention, we skipped over because there's a lot of
25 details associated with these analyses, but as you

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1 read the documents, we look at -- and you just
2 brought up a very important point.

3 We looked at a number of different
4 spent nuclear fuels. You know, despite the fact
5 that I think 85 or more percent of the fuel is now
6 17 by 17, or some variance, whether it be VEN-5,
7 VEN-50FA, what have you. What we did is we looked
8 at -- and we did the same for BWRs, but just to
9 make an example of PWRs, we've done analyses with
10 14 by 14, 15 by 15, 17 by 17, and the main purpose
11 is, when you look at the bounding cladding
12 temperatures of a 14 by 14 fuel, if you had the
13 capacity of loading it at its design basis decay
14 heat load, you've got a lot more heat per rod, and
15 then when you break the communication of that rod's
16 view to the ambient it goes up pretty
17 substantially. You've got a lot more thermal
18 inertia combined with that decay heat load per rod,
19 so you end up with higher PCTs, peak cladding
20 temperatures. So we also did those sensitivity
21 studies.

22 CHAIRMAN BLEY: When you looked at the
23 state of the spent fuel, I'm assuming you -- that
24 already cooled to the limits for handling and
25 shipping.

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1 MR. ADKINS: What we did, here's another
2 conservatism. We actually -- when you look at the
3 bulk inventory of spent nuclear fuel in the states
4 that's in SFSIs, and available for transport right
5 now, a lot of these systems are being loaded at
6 about half their design basis decay heat load. We
7 assumed that they were at their peak, that they
8 were at 100 percent of what they had the capacity
9 of hauling. So that's --

10 CHAIRMAN BLEY: Okay. Well, whether
11 that's conservative or not, some of the -- I know
12 that some of the owners wanted to ship the hottest
13 fuel first rather than the coolest fuel.

14 MR. ADKINS: Right.

15 CHAIRMAN BLEY: They would have been
16 right at the limit when they ship, or they would
17 be, I should --

18 MR. ADKINS: If the casks were loaded
19 with the higher decay heat loads because of the
20 four different in-service inspections that were
21 done by DOE UFDC program, whether it be Calvert
22 Cliffs, Oak Creek, Diablo, and there's one other,
23 and all of the current sites that are loading --
24 doing out loads to the ISFSIs, the unfortunate
25 thing is these systems are not being exercised.

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1 They're being loaded at half their design basis
2 decay heat load, meaning that the fuel has sat so
3 long in the pool that it's relatively cold by the
4 time it goes out to the pad. And then the thing is,
5 those numbers are still -- you still have that
6 exchange as to whether -- when it goes out of the
7 ISFSI and it goes to a transport system, if you
8 look at some of these internally ventilated storage
9 casks, they have about double the capacity, double
10 the decay heat load removal capacity as a transport
11 cask. Okay? But the thing right now, so they're
12 currently outloading even on some of the
13 ventilating casks below the capacity of what a
14 transport, a typical transport system would be able
15 to accommodate, so they are cooler.

16 CHAIRMAN BLEY: They are cool, okay.

17 MR. ADKINS: And we're maximizing those.

18 CHAIRMAN BLEY: One last question, kind
19 of a tutorial for me on cask design. The neutron
20 shield, is that even -- if it's not there, you
21 still meet the limits for these ones being shipped.
22 I assume we need the neutron shield for the case of
23 when we first load the casks --

24 MR. ADKINS: Normal conditions it's --

25 MR. CHANG: Normal condition --

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1 MR. ADKINS: -- required to dose based
2 on contact and dose at a distance. Now one of the
3 things that the Nuclear Regulatory Commission
4 requires, though, is that under any kind of off-
5 normal or accident condition there is -- the
6 parameters for dose are slightly elevated. So as
7 part of that process, the NRC requires that the
8 applicant review their system under an accident
9 condition that they can still meet the dose
10 requirements with the absence of the neutron
11 shield. The gamma shield is a different matter but,
12 you know, in every one of these case studies
13 there's no compelling reason to think that the
14 gamma shields would be compromised. Good question.

15 CHAIRMAN BLEY: Thank you.

16 MR. CHANG: Thermal shield is needed for
17 both NCT and HAC. Now this is Slide 15. Because
18 this slide, we already talk about robustness of the
19 package design. So the next one, for this slide we
20 talk about the transportation element associated
21 with DOT regulation, Part 73. And some action or
22 control we could apply over the years to minimize
23 the accident, the railway accident.

24 The first one, we talk about DOT-49
25 regulation 17485, requirement of buffer car. We had

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1 this one to increase the distance, the space
2 between the spent fuel cask and the other rail car,
3 and we had AAR OT-55, Association of American
4 Railroad OT-55. No pass through that mean a train
5 carrying the spent fuel cask or radioactive
6 material and another train carrying a combustible
7 or flammable material should not pass over each
8 other within the tunnel. And then we had the AAR
9 standard 2043, it's a design standard to have the
10 risk car and the cask car, and the escort car at
11 the end. And then we could even in some specific
12 condition, we need a different and coordinated
13 shipment to minimize all possible, and that's with
14 the package design and the regulation.

15 Department of Energy recommend the
16 railway shipment may be the best idea to ship spent
17 fuel package. I mean, using the railway to ship
18 spent fuel package, that's a DOE recommendation.

19 MEMBER SKILLMAN: Jimmy, let me ask this
20 question. With regard to AAR OT-55, is there a no
21 pass rule for only two tracks in the tunnel, or
22 could that same, or does that same guidance apply
23 also to a three-track tunnel?

24 MR. ADKINS: Right now, as I turn on my
25 microphone, as you probably know, the OT-55 has

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1 been pretty dynamic and is changing very rapidly.
2 And one of the fundamental drivers is the AAR S-
3 2043 spec conveyance, they're articulating
4 conveyances under development. I think right now
5 they're really close to getting the M290 rail car
6 for Navy fuel certified. And, unfortunately, OT-55
7 is trailing fairly substantially, so right now the
8 only no pass envelope that is identified in OT-55
9 is that it's within tunnels because of the
10 potential risk that is added by the tunnel
11 enclosure itself.

12 MEMBER SKILLMAN: But my question is,
13 now that's aimed at a two-track tunnel. Are there
14 three-track tunnels where the AAR OT-55 does not
15 apply?

16 MR. ADKINS: But the no pass rule means
17 that when that consist, the nuclear fuel consist
18 goes through that tunnel it is the exclusive user
19 of that tunnel at that time.

20 MEMBER SKILLMAN: Oh, okay.

21 MR. CHANG: And two.

22 MR. ADKINS: Yes, yes. But the one thing
23 I think that we'll see in OT-55, you know, because
24 OT-55 just incorporated this rule even though it's
25 been on the books for about 10 years now. So what

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1 I'm saying is that we'll probably see even more
2 stringent criteria become -- that revolve around
3 the nuclear consist itself, that it will probably
4 be completely exclusive use. I think that's what
5 DOE NFST is now considering, and some of the
6 reasons are is just from the standpoint of going
7 from region to region. It's a lot easier to certify
8 that consist and its path, and do some of the
9 preplanning and coordination itself. And the
10 primary reason is they don't want to hold up
11 revenue track, and revenue generation for the
12 train.

13 MEMBER SKILLMAN: What's really on my
14 mind is what we're seeing in the east are the bulk
15 oil coming in on these almost mile-long tanker
16 trains.

17 MR. ADKINS: Right.

18 MEMBER SKILLMAN: And these trains can
19 occupy each part of the yard, or each part of a
20 mainline, and if there's a consist that's waiting
21 for the tunnel, I would think the consist -- the
22 nuclear fuel waiting consist -- that consist should
23 wait until that huge mass of combustible cargo is
24 clear.

25 MR. ADKINS: I'm highly confident that's

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1 what we'll see for the outcome.

2 MEMBER SKILLMAN: Because we are seeing
3 it on the east coast, and these are huge, massive
4 consists of brand new identical tankers, and
5 they're carrying bulk into the east coast is what
6 they're doing.

7 MR. ADKINS: And like you say, a mile
8 long.

9 MEMBER SKILLMAN: Thank you.

10 MEMBER BALLINGER: The Navy has been
11 shipping fuel in this configuration for years. The
12 290 cask, they actually had a rail crossing
13 accident with one of those casks. There was no fire
14 or anything, but then they had -- they've also had
15 an earlier design cask, I forget what the number
16 is, where one of them tipped over in the rail yard,
17 and just fell over and they just righted it back up
18 and kept on going. So there's a lot of history with
19 this configuration.

20 MR. ADKINS: Yes.

21 MEMBER SKILLMAN: Well, this is a
22 configuration for all of the TMI-2 fuel. If all of
23 those consists were just like that time and after
24 time, and the problem was getting the permissions
25 from Pennsylvania, from Ohio, and from Chicago to

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1 get to Idaho, north of Idaho.

2 MR. ADKINS: Yes.

3 MR. SCHULTZ: Jimmy, the last bullet,
4 preplan and coordinate shipments, it's kind of a
5 summary that this also would be done. Is there any
6 particular approach or regulation that you see
7 coming down the road that will cause that to be
8 more than an expectation?

9 MR. BOROWSKY: Yes, this is Joe
10 Borowsky. The preplan and coordinate shipments
11 actually is the wording that you'll see in 10 CFR
12 Part 73.37, so that's basically a requirement that
13 such activities are performed prior to the shipment
14 of spent fuel.

15 MR. ADKINS: And requiring NRC
16 engagement.

17 MR. BOROWSKY: Yes.

18 MR. SCHULTZ: Okay. So that's a summary
19 of what will be done associated with that
20 expectation to document.

21 MR. BOROWSKY: That's correct, Part
22 72.37.

23 MR. CHANG: So to come to conclusion, on
24 the railway fire accident, so the package evaluated
25 are shown to be training to bust in response to a

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1 real life railway fire that is beyond the
2 regulation fire. With a temperature than 1475
3 Fahrenheit, and the time period is much longer than
4 30 minute. And the current NRC regulations and the
5 package standard provide a high degree of
6 protection, again this radioactive material during
7 real life railway transportation accident. However,
8 we understand any accident could happen again so we
9 continue to watch and see what we need to do to
10 minimize, what we need to do in the regulation to
11 minimize the accident, and we want to provide
12 health and public health and safety. And that's the
13 concern we work on with this research. And that's
14 my conclusion on the railway fire accident.

15 CHAIRMAN BLEY: Okay. Jimmy, thank you.
16 Anything more for Jimmy? We're going to take a
17 break now for 15 minutes. We'll come back at 10
18 after 10 on that clock. Joe, you've got a few more
19 slides than Jimmy had. We may have to speed up
20 through some of them, especially the descriptive
21 things. I'm sorry?

22 MR. ADKINS: It might go a little faster
23 because we've discussed quite a few things that
24 actually go into those analyses, too.

25 CHAIRMAN BLEY: Yes, that's what I would

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1 hope, so we'll see how it goes, but after an hour
2 we might have to speed up a little bit. We have to
3 be finished before noon. Okay, we will recess at
4 this time for 15 minutes.

5 (Whereupon, the above-entitled matter
6 went off the record at 9:53 a.m. and resumed at
7 10:10 a.m.)

8 CHAIRMAN BLEY: We'll turn it over to
9 Joe.

10 MR. BOROWSKY: Now we'll transition to
11 the roadway severe fire accidents that were
12 analyzed, including Caldecott Tunnel, MacArthur
13 Maze, and the Newhall Pass Tunnel fire scenarios.

14 I just want to mention that as with the
15 Baltimore Tunnel fire accident, none of these
16 accidents involved radioactive material. The case
17 studies described today are the results of
18 essentially numerically placing a transportation
19 package within an environment defined by real world
20 accidents. Next slide, please.

21 The first accident study was the
22 Caldecott Tunnel fire, and you see the picture
23 below. It's the roads leading to and from the
24 tunnel. West Portal bore number 3 is where the
25 accident actually occurred, and that's the opening

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1 on the far left. In this scenario, a tanker truck
2 and trailer overturned and caught fire within the
3 tunnel. The tank trailer cargo included 8,800
4 gallons of gasoline and the overall fire duration
5 based on NTSB investigation is 2.7 hours, but the
6 intense fire duration was determined to be 40
7 minutes. Next slide.

8 The analysis methodology undertaken
9 include using NIST's Fire Dynamic Simulator code to
10 determine the thermal boundary conditions. These
11 thermal boundary conditions were then applied to
12 the ANSYS on an element model, NAC-LWT
13 transportation package.

14 Some conservatisms of the model include
15 using the peak tunnel temperatures, even if the
16 package surface could not see that particular
17 location, and also neglecting the thermal shielding
18 effect of the package conveyance. Basically, the
19 package was suspended at an elevation corresponding
20 to the height of the flatbed transporting the
21 package. Next slide, please.

22 The FDS 3D model was approximately 787-
23 foot long, 18-foot wide, and 28 -- excuse me, 18-
24 foot high and 28-foot wide. For the 40-minute
25 duration fire the FDS code showed a maximum gas

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1 temperature of 1965 degrees Fahrenheit. The figure
2 on the right shows the temporal temperature
3 distributions at three tunnel elevations, basically
4 the ceiling, the wall midline, and the floor center
5 line. Using these boundary conditions, they were
6 then applied to the ANSYS finite element analysis
7 model to perform thermal analysis on the LWT
8 transportation package.

9 The results from the analysis showed a
10 peak cladding temperature of 544 degrees
11 Fahrenheit, peak clouding temperature of 1288
12 degrees Fahrenheit, and the gamma shield
13 temperature of 622 degrees Fahrenheit. Next slide.

14 The next roadway fire accident --

15 CHAIRMAN BLEY: For these -- that one
16 and the rest we're going to see, did you guys do
17 something similar to what Harold described where
18 you ran multiple cases and tried to draw some
19 conclusions? You still not doing anywhere along the
20 line of best estimate in looking at uncertainties.
21 You're always doing a conservative, what you think
22 is a conservative calculation.

23 MR. BOROWSKY: Yes. We basically apply
24 the -- I'll say what we feel are boundary
25 conditions that are beyond -- they may be even

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1 beyond what the accident described.

2 CHAIRMAN BLEY: Okay. And ran notable
3 cases to kind of bound the results?

4 MR. BOROWSKY: Yes. In fact, for the
5 Caldecott Tunnel fire, for example, the LWT can be
6 transported either within or outside of an ISO
7 container, so you'll see some of the results
8 presented later on, the -- you'll see that
9 basically the temperatures, different temperatures
10 associated with those two conditions.

11 CHAIRMAN BLEY: Okay.

12 MEMBER SKILLMAN: At the bottom of that
13 slide you show the 622 Fahrenheit, 328 C for the
14 gamma shield. Is that temperature constrained by
15 the latent effusion of the lead? Is that what keeps
16 that temperature from going above that?

17 MR. BOROWSKY: That's essentially right.
18 The lead shield reached 622 degrees Fahrenheit at
19 different points within the package. So it's not
20 like it was uniformly at 622, so there wasn't --
21 let's put it this way. There wasn't a complete
22 phase change that occurred.

23 MEMBER SKILLMAN: Okay, thank you.

24 MR. BOROWSKY: The next roadway fire
25 accident studied was the MacArthur Maze fire

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1 scenario. Next slide, please.

2 The MacArthur Maze fire accident took
3 place on the I-880 connector of MacArthur Maze
4 interchange. A tanker truck and trailer overturned
5 and caught fire on I-880. This was actually a
6 single vehicle accident. The tank trailer cargo
7 included 8,600 gallons of gasoline. I show two
8 figures in order to put this accident in a little
9 bit of perspective. On the left you see the lower
10 I-880 roadway, and the collapsed I-580 overpass
11 resting on top of it. On the right you see the
12 intense fire in the area between the lower I-880
13 road and the I-580 overpass.

14 Now this intense fire weakened the
15 steel girders collapsing the two spans on the
16 roadway below it, and so it formed an enclosure
17 because of that collapsed roadway. But this -- even
18 though it was an enclosure there was sufficient
19 opening in order to allow combustion air flow.

20 It's also worth mentioning that the
21 timeline information about this fire was available
22 because it was recorded by camera from a nearby
23 municipal waste treatment facility.

24 MEMBER SKILLMAN: Before you change that
25 image, would you explain what we see basically dead

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1 center? It almost appears as though the concrete
2 has changed form. It appears to be contoured as
3 opposed to cast slab. Maybe my eyes are deceiving
4 me, but that's what I imagine when I see this, and
5 I'm wondering if there is another phenomenon on
6 concrete degradation that we haven't thought much
7 about? In other words, is that concrete --

8 MR. BOROWSKY: The picture on the left?

9 MEMBER SKILLMAN: Yes, on the left.

10 MR. BOROWSKY: Well, again I'm not quite
11 sure what you're necessarily seeing, but the
12 roadway sagged. Basically, the steel girders sagged
13 somewhat and so I would suspect that the overlaying
14 concrete kind of followed that form to a certain
15 extent. But in terms of the details of the -- of
16 any type of concrete behavior, I really can't speak
17 to that.

18 MEMBER SKILLMAN: It just appears to me
19 to be an odd configuration of concrete that I would
20 think is generally brittle, it fractures, it comes
21 apart in pieces. That almost gives the appearance
22 of having flowed, and I just don't know what I'm
23 looking at. And I'm not trying to create a stir, I
24 don't know what I don't know, and I'm thinking oh,
25 that's odd.

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1 MR. BOROWSKY: Yes, I just don't know at
2 what point that picture was taken, whether it was
3 taken a few hours or days, and there was some clean
4 up. I'm not familiar with at what point that image,
5 that photograph was taken.

6 MEMBER SKILLMAN: That was a curiosity
7 question. Thank you.

8 MR. BOROWSKY: Oh, sure. Next slide,
9 please.

10 For analysis purposes, there were three
11 events associated with this accident. The fire
12 before the I-580 collapse, and the fire after the
13 collapse, and the Fire Dynamic Simulator code was
14 used for both events. The pre-collapse fire
15 duration was 37 minutes, and the fire temperature
16 was 2012 degrees Fahrenheit. And this was taken to
17 be a fully engulfing fire. The post-collapse fire
18 duration was 71 minutes, and the fire temperature
19 was 1652 degrees Fahrenheit. And this was also
20 taken as a fully engulfing fire.

21 It's also useful to point out that
22 there was some metallurgical analysis performed on
23 the samples from the accident site, and depending
24 on the particular sample temperatures between 1228
25 degrees Fahrenheit to 1657 degrees Fahrenheit were

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1 determined. And these temperatures basically
2 confirm that high temperatures existed within this
3 fire.

4 CHAIRMAN BLEY: Joe, when you say it was
5 taken as, it sounds like one more conservatism. You
6 had movies of this one. Was it fully engulfing, or
7 essentially fully engulfing from what you could
8 see?

9 MR. BOROWSKY: Right. Specifically for
10 post-collapse fire duration, you know, the I-580
11 collapsed on that, and so that would have
12 prevented, just because of blockage, a truly fully
13 engulfing fire. So during the post-collapse fire
14 duration, that 71-minute duration, we assume it was
15 fully engulfing.

16 CHAIRMAN BLEY: Okay.

17 MR. BOROWSKY: And the effect of the
18 collapsed overpass was only during the cool down
19 phase after the fire was extinguished. I'll mention
20 this a little bit later. This I-580 acted as a
21 blanket, a thermal barrier, so that thermal
22 barrier, the blockage was taken after the -- or
23 during the cool down phase such that the post-
24 collapse was treated, or how we envisioned it to be
25 a fully engulfing fire. Next slide, please.

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1 Now there are many aspects of the fire
2 scenario that are more severe than the hypothetical
3 accident condition fire defined by 10 CFR 71.73.
4 For example, for the pre-collapse fire there was a
5 higher temperature and longer duration, 1100
6 degrees C for 37 minutes versus 800 degrees C for
7 30 minutes for the regulatory fire. And for the
8 post-collapse fire, again a higher temperature and
9 in this situation a much longer duration, 900
10 degrees C for 71 minutes.

11 Other severe aspects of the fire
12 included the impact of the free-falling overhead
13 span on the package. And the post-fire cool down of
14 the package assumed the covering by the concrete
15 blanket. And that's kind of what I alluded to
16 earlier. The package was also chose to be in the
17 most adverse location during each stage of the
18 scenario. It was on the roadway in the fully
19 engulfing fire for both the pre and post-collapse
20 fires. Again, it speaks to what I had mentioned
21 earlier about not taking into account the shielding
22 effect from the collapsed roadway. And, in
23 addition, this also ignored the shielding effect
24 from the package conveyance.

25 Another item to note is that the impact

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1 location and orientation was determined by analysis
2 of multiple cases. Basically, which location would
3 form or have the greatest potential for deformation
4 by the falling of the I-580 overpass. And, again,
5 the other adverse location was the fact that it was
6 under a concrete blanket for the extent of the
7 post-fire cool down.

8 In addition to using the FDS code in
9 order to determine the thermal boundary conditions
10 both COBRA-SFS, which was developed by Pacific
11 Northwest National Laboratories, and ANSYS were
12 used to evaluate the General Atomics GA-4 LWT
13 package. And, in addition, LS-DYNA was used to
14 model the effect of the falling I-580 overpass.
15 Next slide, please.

16 So here we have some temperature
17 results of the COBRA-SFS and ANSYS thermal analyses
18 of the GA-4 package. For the pre-collapse portion
19 of the fire, the first 37 minutes, the peak
20 cladding temperature was found to be about 1020
21 degrees Fahrenheit. There was an O-ring temperature
22 of 250 degrees Fahrenheit, and the gamma shield was
23 250 degrees Fahrenheit.

24 The results show for the post-collapse
25 portion of the fire, the results show a peak

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1 cladding temperature raised considerably, 1,425
2 degrees Fahrenheit, an O-ring temperature of 770
3 degrees Fahrenheit, and the gamma shield
4 temperature of 1,490 degrees Fahrenheit.

5 I'd like to point out the top picture
6 on the right. This picture represents the post-
7 collapse situation where the I-580 span covers the
8 GA-4 package and hinders the removal of heat during
9 the post-fire cool down. And for the post-fire cool
10 down period, the results show a peak cladding
11 temperature of 1,400 degrees Fahrenheit, and a high
12 O-ring temperature of 1,150 degrees Fahrenheit.

13 I mentioned a little bit earlier that
14 an ANSYS thermal model of the I-580 span was also
15 made in order to determine a temperature for
16 subsequent structural analysis. And for this
17 particular LS-DYNA analysis, steel girders at 1,800
18 degrees Fahrenheit were used in order to impart the
19 impact load of the falling I-580 overpass on the
20 package. And four impact orientations were
21 considered, basically the girders along the package
22 or across the package, whether they impacted the
23 lid or the trunnions. For all these conditions
24 there was only local classic strain at the package
25 outer wall. There was no gross failure or rupture

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1 of the package.

2 And as shown in the lower figure on the
3 right, relatively speaking the girders are thin and
4 somewhat weak at high temperatures, and so they're
5 the ones that actually deform on impact.

6 MEMBER SKILLMAN: Joe, how did you
7 choose the impact geometry? A long cylinder is
8 weakest at its dead center on its longitudinal
9 axis, and so had you chosen perhaps one orientation
10 versus another you might have had greater
11 deformation and hence, either rupture or
12 deformation leading to leakage, particularly on the
13 seal. So how did you choose what is a defensible
14 orientation?

15
16 MR. BOROWSKY: Right, that's a good
17 question. There were a number of what I'll call
18 orientations that were analyzed. The image that you
19 see on the bottom right was the case where the
20 girders were what I'd call across the package. And
21 that was considered because in that particular
22 situation you actually have two girders contacting
23 the package just by the space between the girders.
24 But there were three other orientations considered;
25 one was, and this may be kind of what you're

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1 saying, there was one where the package was
2 positioned so that it would be aligned with the
3 entire length of the package. And then there was
4 one that was also oriented so that it would impact
5 the lid or the seals would be -- you know, would
6 have the most direct effect on the seals. And then
7 the final orientation was on the trunnions itself.
8 And again, in all these orientations the classic
9 deformation essentially is just at the outer wall.
10 It never penetrated deep into the package. The
11 local classic strain was small. I think the reason
12 why the classic strains were small is kind of like
13 you see at the bottom image there, is these steel
14 girders, yes, you know, we're familiar with them
15 when they're at ambient temperature. You know,
16 they're strong but, you know, assuming that they're
17 at 1,800 degrees Fahrenheit, they become relatively
18 weak. And from the LS-DYNA result that we see at
19 the bottom image, you know, that's the one that
20 deforms, basically. That's the one that -- that's
21 the component that gives. It's not the package,
22 it's --

23 (Off microphone comment.)

24 MR. ADKINS: One thing I was going to
25 add just to give you some of the particulars. The

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1 girders themselves, the strength is reduced to
2 about 10 percent of its capacity at these elevated
3 temperatures, so that's one stray. The core of the
4 package that's kind of the outer protection of the
5 inner containment boundary is depleted uranium at
6 multiple inches thick. And then this particular
7 scenario that you're looking at, interestingly
8 enough this kind of came out to be the worst case
9 from the middle girder dropping through the center
10 section like you had stated, as well as impacting
11 the closure, because you get secondary stresses
12 right where the bolted closure is and where it
13 tapers out into the main body of the containment
14 boundary, where the stresses were at the highest
15 for any of the scenarios that we evaluated.

16 Now interestingly enough, when you look
17 at the orientation, the way that cask is sitting on
18 that, we had a picture where it showed the beams
19 looked exactly like this, the bent structure that
20 they dropped just to kind of do a rudimentary
21 comparison, and the giggle test, if you will. But
22 then for the thermal loading it's a super position
23 of multiple things. It's this oriented so you end
24 up with structural. Then with the package rotated
25 up against the Jersey barrier with the roadway

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1 falling over it, and all of these things couldn't
2 take place at the same time, a further
3 conservatism.

4 MEMBER POWERS: What kind of peak
5 temperature did you get in the depleted uranium?

6 MR. BOROWSKY: The peak temperature --
7 here, I have that. The peak temperature for
8 MacArthur Maze depleted uranium was about 1,480
9 degrees Fahrenheit.

10 MEMBER POWERS: 1,480 Fahrenheit. Do you
11 know how long that kind of temperature was like
12 that?

13 MR. BOROWSKY: How long it was at that
14 temperature?

15 MEMBER POWERS: Yes.

16 MR. BOROWSKY: Well, the fire itself,
17 the total fire, the pre-collapse 37 minute, and the
18 post-collapse 71 minutes, so the total fire was 108
19 minutes. It only -- I'm looking at the pre-collapse
20 portion, the peak at the first 37 minutes was 1,250
21 degrees Fahrenheit so it reached the 1,480
22 somewhere between the 37 minutes and the 71
23 minutes. Once the fire ceases the outer -- what
24 I'll call the outer portions of the package begin
25 to cool. So assuming a step change from, you know,

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1 for the full 71 minutes, it could be approximately
2 up to that period of time, but I suspect --

3 MEMBER POWERS: The reason I'm asking
4 that question is, there is an inner-metallic
5 reaction between uranium and steel. And these
6 temperatures you ordinarily don't worry about it,
7 but I'm used to durations that are short. I don't
8 know what happens, and I don't -- I try to keep my
9 uranium from getting hot. Do you guys worry about
10 that kind of thing when people use depleted uranium
11 in these packages?

12 MR. BOROWSKY: That particular issue was
13 not addressed in this analysis that I know of, but
14 I'd probably want to defer to like a material
15 science type person for that. But I suspect it's
16 two things, and basically what you had said. It's
17 temperature and time, but I guess it -- there would
18 have to be -- one would have to look at those two
19 parameters together in order to --

20 MEMBER POWERS: Yes, I simply don't
21 know. I mean, I know the interaction is exothermic,
22 and if you were talking about molten uranium then I
23 would tell you oh, my God, and I'd clutch my heart,
24 fall on the floor, and all kinds of things like
25 that. But to go from a solid into a self-

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1 propagating exothermic reaction, that's a
2 complicated analysis that I certainly can't do in
3 my head. I know that it was an issue that Dr. Rempe
4 raised in connection with a PRA analysis, and it
5 was pooh-poohed fairly definitively by the speaker
6 at the time, but I don't think he understood what
7 exactly she was talking about. They know in these
8 fires -- I mean, he had peak temperatures on the
9 order of 1,000 degrees Fahrenheit which I think we
10 could find, and they were very transient in nature.
11 Here you're talking about like an hour, I mean,
12 lots of minutes, somewhat higher, not enormously
13 higher. But I can change the scenario a little bit
14 and get into longer durations, little bit higher
15 temperature. I just simply don't know what happens
16 where with that depleted uranium. It is highly
17 electro positive metals when they see iron are just
18 going to certainly have the potential of having
19 exothermic interactions. I mean, it's something to
20 -- that your computer code doesn't have built into
21 it, so you need to do something exogenous. And
22 since nobody voluntarily does these things, you're
23 not going to find a lot of data on it.

24 MR. BOROWSKY: Okay, thank you. That is
25 a good point.

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1 MEMBER SKILLMAN: I would like to ask a
2 question, please. We had a marvelous tour up at
3 NIST here not so long ago, and one of the
4 laboratories that we visited was a laboratory where
5 a gentleman was testing O-rings at high
6 temperature, and they were O-rings that are
7 intended to be used for these casks. And these were
8 metallic rings, and he was driving temperatures of
9 12-1,500, 2,000 degrees Fahrenheit. He was really
10 pushing the temperatures.

11 What are the O-rings in your analysis,
12 and what are they -- what is their temperature
13 limit? What is their composition, and what is
14 their temperature limit?

15 MR. BOROWSKY: Right. I can answer that
16 question now. It would also be discussed later on,
17 but for the MacArthur Maze the O-ring temperature,
18 excuse me, the O-ring material is EPDM, and its
19 continuous -- let me see. Its continuous use
20 temperature is 302 degrees Fahrenheit for EPDM. In
21 the next portion of the presentation we discuss the
22 consequences of these temperatures, and to make it
23 short, we assume that the seal fails.

24 MEMBER SKILLMAN: All right.

25 MEMBER POWERS: I mean that is a fairly

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1 conservative assumption. You mention that you have
2 1,150. We did look at some of these things, and I
3 mean, you're right, you take it above 300 or so
4 degrees Fahrenheit and it's not really an O-ring
5 any more. As long as it remains bolted you don't
6 really have like an open gap in there any more.

7 MR. BOROWSKY: That's correct.

8 MEMBER POWERS: Suddenly -- you're not
9 going to use it again, but that probably goes
10 without saying here.

11 MR. BOROWSKY: You probably not going to
12 remove it either. It's going to be cinders.

13 MEMBER POWERS: Well, we did -- we ran
14 these tests and looked at over-driving these things
15 and whatnot, and they remained sealed and whatnot.
16 When they opened them up you couldn't reseal them.
17 Okay. But they didn't -- they were in operation and
18 they were held for hours at these temperatures.
19 They didn't open up making huge gaps that you would
20 drive trucks through and things like that. So
21 assuming failure is very conservative --

22 CHAIRMAN BLEY: And you did --

23 MEMBER POWERS: You had the complexity
24 that the bolts are getting hot and so relaxing some
25 of the temperature, I mean some of the strain on

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1 the -- the squeeze on the O-ring and things like
2 that, I mean, it's not a catastrophic failure that
3 occurs.

4 MR. BOROWSKY: That's correct.

5 CHAIRMAN BLEY: Well, you also have the
6 report. I think you provided this, but it's
7 available publicly on what Dick was citing. In NIST
8 they're both metallic and polymer O-rings, so you
9 didn't rely on that study.

10 MR. BOROWSKY: No. I mean, we took that
11 --

12 CHAIRMAN BLEY: The assumption that
13 they'll leak.

14 MR. BOROWSKY: That's correct.

15 CHAIRMAN BLEY: Yes, some rate, I
16 forget.

17 MR. BOROWSKY: You're right, the
18 experimental work that NIST performed showed that
19 the seals, even though they were much higher than
20 their continuous use temperature, and for a fairly
21 long period of time, they still retained some
22 sealing capacity, what I'll call sealing capacity.
23 The material itself was degraded, but basically
24 that degraded material gummed up the works so to
25 speak.

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1 CHAIRMAN BLEY: Right. That's kind of
2 the same place Dana was. But this is recent work.
3 They were still working on it when we were out
4 there. But you didn't rely on that at all.

5 MR. BOROWSKY: No, we just -- we took a
6 separate approach with let's just --

7 MR. ADKINS: Partly due to the fact that
8 the two studies were being done in parallel, too.

9 CHAIRMAN BLEY: Yes. I kind of sense
10 even if it had been done, you seem to like piling
11 on the conservatisms.

12 MEMBER SKILLMAN: It's assumed here that
13 the package was assembled properly. In other words,
14 that the closure and the O-ring were in the
15 geometry that they were intended for the design of
16 this cask in accordance with the certificate of
17 conformance. I wonder if you've ever considered
18 what happens if the cask is really one bolt off, in
19 other words the lid is not on, it's one bolt or two
20 bolts off. And so while it appears sealed, in fact,
21 it isn't sealed.

22 MR. BOROWSKY: Just real quick. For Part
23 71 transportation, we basically -- licensees
24 typically have to file what's called the ANSI M-
25 14.5 leakage standard. And in addition to testing

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1 the containment boundary during fabrication stage,
2 after maintenance and stuff like that, one of the
3 tests is the pre-shipment test, so they perform
4 basically a pre-shipment leakage test in order to
5 check the issue that you just raised, which was a
6 good point. It's the hey, before we ship it out
7 let's make sure everything is together, and so that
8 is part of the procedures that they have to
9 perform.

10 MEMBER SKILLMAN: Thank you.

11 MR. BOROWSKY: The final case study was
12 the Newhall Pass fire. This is the Newhall Pass
13 fire at the I-5 truck route underpass tunnel. And
14 below is a photograph of the tunnel and the
15 surrounding road system to, again, kind of put it
16 in perspective.

17 This was a chain reaction traffic
18 collision of 33 tractor trailer trucks. The first
19 started near the tunnel exit and spread the full
20 length of the tunnel. Twenty-four tractor trailers
21 were destroyed. Although none were carrying
22 hazardous material, there was combustible material.

23 MEMBER BROWN: Excuse me. I may be
24 wrong, but where is the tunnel? This looks like
25 nothing but roadways to me. Oh, it's underneath,

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1 okay. All right.

2 MR. FORT: The exist and then pass
3 beneath the I-5.

4 MEMBER BROWN: Okay, thank you.

5 MR. BOROWSKY: Again, although none of
6 the vehicles were carrying hazardous material,
7 there was, of course, combustible material,
8 including diesel within the truck tanks, tires,
9 sheet aluminum on the semi-trailers, wood, cotton,
10 sugar, cardboard containers, and fruits and
11 vegetables.

12 MEMBER SKILLMAN: Did the sugar catch
13 fire? That's a wicked fire, that's like charcoal.
14 That's terrible.

15 MR. BOROWSKY: Yes, high-energy content,
16 right. The fire duration was estimated between
17 three and five hours, the local fires on the
18 individual vehicles were estimated between a half
19 hour to one hour as the fire spread through the
20 tunnel, as it basically progressed. Next slide,
21 please.

22 As with the other fire scenarios, the
23 FDS code was used to determine the global boundary
24 conditions but this was really an involved
25 analysis, it involved tests for a number of

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1 reasons. First of all, of course, there were a
2 large number of vehicles that had to be considered.
3 There was also uncertainty associated with the
4 combustible material for each vehicle, uncertainty
5 in the burn rate of that combustible material, and
6 the uncertainty of the fire spread rate, so the FDS
7 code was put to good use and looked at a number of
8 parameters.

9 Specifically, six cases were
10 considered, a slow and a fast burn rate. There was
11 a range of fire spread rates, and variation of fuel
12 budget for each of the vehicles within the fire.
13 The upper image on the right shows the severity of
14 the local fire associated with a vehicle, and the
15 lower image shows the extent of the FDS, the Fire
16 Dynamics Simulator model. Next slide, please.

17 There are aspects that are more severe
18 associated with this fire than the hypothetical
19 accident condition fire defined by 10 CFR 71.73.
20 The peak fire temperature, you know, varied from
21 854 degrees C to 1,088 degrees C.

22 MEMBER POWERS: The change in units
23 that you made for the drug is to facilitate is our
24 understanding?

25 MR. BOROWSKY: Yes, actually that is

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1 why they did.

2 MEMBER POWERS: It's been Fahrenheit
3 all the way through and now all of a sudden you
4 switch to Centigrade. That makes it really easy.

5 MR. BOROWSKY: I was trying to help
6 you.

7 Now, the purpose for that was I wanted
8 to more easily visualize the difference with the
9 800 degrees C and the 30 minute fire duration
10 defined by the regulations.

11 So, I want to quickly eyeball how much
12 different that fire temperature is.

13 MEMBER BROWN: You could have specified
14 the 800 and --

15 MR. BOROWSKY: I could have did that,
16 too, that's right.

17 The local fire duration at specific
18 truck locations range from 26 minutes to
19 approximately 68 minutes, so again, for the most
20 part, greater than the 30 minute duration.

21 And, for this particular scenario,
22 there was another issue. There was the preheating
23 of the package, depending on the location in the
24 tunnel and especially the fact that the fire
25 progressed from the end towards the beginning of

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1 the package meant that, especially the vehicles at
2 the beginning of the tunnel saw a fairly large or
3 long period of preheating. And, in some cases, it
4 was up to four hours.

5 As I mentioned earlier, the FDS code
6 was used to determine the most adverse condition
7 from a matrix of cases. For the six cases studied,
8 there were actually then two package or vehicle
9 locations studied on the hottest fire location
10 which took place in the middle of the tunnel. And,
11 the longest preheating fire location which was just
12 past the tunnel entrance.

13 And, based on these conditions, ANSYS
14 and COBRA-SFS were used to perform thermal analysis
15 of the GA-4 package for each case.

16 Next slide?

17 There are a number of conservativisms
18 considered for this -- both for the COBRA-SFS and
19 ANSYS models including choosing a conservative
20 combustible mass for each vehicle within the
21 tunnel, assuming the entire combustible mass of
22 each vehicle was fully consumed by the fire.

23 There was a walk down or walk through
24 after the fire and that showed that, in fact, not
25 all of the carbo was consumed in the actual fire.

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1 Assuming the peak local temperature was
2 applied to -- or applied from the fire dynamic
3 simulator code output, and again, we neglected the
4 shielding effect of the package conveyance such
5 that there wasn't -- or such that the heat input
6 from the fire was all towards the package.

7 Next slide, please?

8 So, here are the results from the
9 COBRA-SFS and ANSYS results that, you know,
10 basically show high component temperatures.

11 For the longest preheating -- for the
12 long preheating fire location with a 64 minute
13 local fire duration, the decladding temperature
14 ranged from 834 degrees Fahrenheit to 1,020 degrees
15 Fahrenheit.

16 The lid seal temperature was 649
17 degrees Fahrenheit.

18 For the hottest fire location with a 78
19 minute local fire duration, peak cladding
20 temperature varied from 994 to 1,217 degree
21 Fahrenheit. And, there was a lid seal peak
22 temperature of 545 degrees Fahrenheit.

23 Next slide, please?

24 So, you know, at this point, we'll
25 transition from the description, so to speak, of

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1 the fire accidents in the area to the consequences.

2 We've seen that the Caldecott Tunnel,
3 the MacArthur Maze and the Newhall Pass Tunnel fire
4 scenarios were severe fires relative to the
5 hypothetical accident condition fire defined by the
6 regulations.

7 And so, again, we'll now look at the
8 consequences of that.

9 Next slide, please?

10 First, we'll look at the various
11 components of the NAC-LWT package as it relates to
12 the Caldecott Tunnel fire scenario.

13 Now, the neutron shield is assumed lost
14 as a result of the fire hypothetical accident
15 condition. And, the dose is still within
16 regulatory limits.

17 As mentioned earlier, this is a design
18 basis assumptions satisfied by all the packages
19 studied.

20 For the gamma shield, some of the lead
21 reached its melting point between 23 to 34 minutes
22 after the start of the 40 minute fire. And so,
23 there's only the potential localized melting which
24 would still, you know, it would still provide
25 shielding.

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1 For the metallic lid seal, the peak
2 temperature, you know, varied from 735 to 794
3 degrees Fahrenheit, depending on whether it was
4 within or outside the ISO container. But even so,
5 it was below its 800 degrees Fahrenheit continuous
6 use limit.

7 For cladding, its peak temperature
8 varied from 535 to 544 degrees Fahrenheit,
9 depending on, again, whether it was outside or
10 within an ISO container. And, that's also well
11 below its limits.

12 Next slide, please?

13 Now, the issue really comes up with the
14 vent o-ring seals and the drain port o-ring seals.
15 These are made of polymeric materials, TFE or
16 Viton. And, the peak temperatures in these
17 regions, again, varying between the 1,035 to 1,288
18 degrees Fahrenheit exceeded the continuous use
19 limit for TFE. The continuous use limit is 735
20 degrees Fahrenheit and Viton is 550 degrees
21 Fahrenheit.

22 And so, the seals were conservatively
23 assumed to have failed at these high temperatures.

24 For this analysis, excuse me, and so
25 for -- so the question becomes what is the

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1 potential release through these failed seals?

2 Since cladding was below its allowable
3 temperature, the source of the released material
4 could be CRUD part of this from the exterior of the
5 cladding. And, this was calculated to have an
6 activity of .01 curies which translates into a .001
7 A-2 quantity, and that's below the regulatory limit
8 of an A-2 per week.

9 Next slide, please?

10 Now, for the MacArthur Maze fire
11 scenario and the consequences for the GA-4 package,
12 the peak temperature was approximately 1,480
13 degrees Fahrenheit and that's below its 2,070
14 degree Fahrenheit melting point temperature for
15 depleted uranium.

16 The peak temperatures of the cask lid,
17 the drain valve seal and the gas sample port seal
18 were quite high from 1,130 to 1,170 degree
19 Fahrenheit. And, you know, as mentioned earlier in
20 our discussion, this exceeded the continuous use
21 temperature limit of the EPDM seals.

22 And so, for this analysis, it was
23 assumed that the seals failed.

24 In regards to the fuel, the peak
25 cladding temperature is predicted for both the

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1 ANSYS and COBRA to reach nearly 1,400 degrees
2 Fahrenheit during the post-fire cool down. This is
3 a high temperature and it exceeds the short-term
4 and estimated burst temperature limits.

5 Next slide, please?

6 And so, it's worthwhile to take a
7 little bit closer look at the potential for fuel
8 failure.

9 The FRAPCON-DATING and the FRAPTRAN
10 fuel performance codes were used to predict
11 cladding behavior. FRAPCON-DATING relies on peak
12 rupture models and FRAPTRAN relies on burst rupture
13 models.

14 Both models predicted fuel failure of
15 MacArthur Maze basically because the 1,400 degree
16 Fahrenheit cladding temperature was above the
17 calculated failure temperature before the cladding.

18 Next slide, please?

19 So, you know, with there being
20 potential issues with the o-ring seals and the
21 cladding, it becomes necessary to estimate a
22 potential release.

23 The release model was based on the
24 pressure in the package and the leakage between the
25 lid and flange for the lid clamping force.

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1 The potential release includes the
2 fission products and spent fuel particles in
3 addition the CRUD particles assumed to have fall
4 from the cladding surface.

5 The total release was calculated to be
6 0.24 A-2 quantity which is below the regulatory
7 limit of A-2 per week value limit value.

8 And, it's worthwhile to note that this
9 conservatively neglects particulates settling once,
10 or excuse me, after a rod bursts. And, it also
11 conservatively assumes that there is no restriction
12 on the size of particles passing through the small
13 gap between the lid and flange.

14 Next slide, please?

15 Now, we'll discuss the Newhall Pass
16 fire accident scenario and the consequences on the
17 GA-4 package.

18 For the gamma shield, the peak
19 temperature was calculated to be 1,200 degrees
20 Fahrenheit. And, again, that's below the melting
21 temperature of 2,070 degrees Fahrenheit for
22 depleted uranium.

23 The o-ring seals for the lid, the drain
24 valve and the gas sample port exceeded the
25 continuous use temperature limit of the EPDM seal

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1 at 302 degrees Fahrenheit. And, as Matt has
2 mentioned earlier, for this analysis, the seals are
3 assumed to fail.

4 Next slide, please?

5 So, as with the MacArthur Maze
6 analysis, the COBRA-SFS and ANSYS results were used
7 as input to the fuel performance codes.

8 Based on that input, FRAPCON-DATING
9 predicted no fuel failure, and likewise, FRAPTRAN
10 predicted no fuel failure based on the COBRA-SFS
11 results.

12 But, the peak cladding temperature
13 predicted with ANSYS was generally higher than the
14 COBRA-SFS for each case.

15 And so, for three of the ten analyzed
16 cases, based on the ANSYS results, there was found
17 that there was potential for failure from the --
18 based on the FRAPTRAN analysis.

19 And, again, I want to repeat that the
20 o-rings seal failure also would allow the potential
21 for release of CRUD particles that are on the
22 exterior of the cladding.

23 Next slide, please?

24 Now, recall with the MacArthur Maze
25 analysis, the release model was based on the

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1 pressure within the package. So, we see in the
2 figure on the slide that the MacArthur Maze cavity
3 pressure bounded, the Newhall Pass fire scenario
4 cavity pressure.

5 And, basically, therefore, consequences
6 were conservatively assumed to be the same as the
7 MacArthur Maze fire scenario with the total release
8 being below the regulatory limit.

9 MEMBER SKILLMAN: Why did you do that?
10 Did you simply do $PV = mRT$ on the Newhall Pass and
11 say, golly, it's so far below MacArthur Maze that
12 we don't have to do the analysis?

13 MR. BOROWSKY: Well, I mean in terms of
14 all the analyses leading up to that, yes. I mean,
15 once -- because it's the same package. The
16 content's the same and so, the only thing that
17 could drive any release was that pressure within
18 the cavity pressure.

19 So, essentially, yes. I mean, the fact
20 that that pressure was below -- much further below
21 the MacArthur Maze, it couldn't be any worse than
22 that.

23 MEMBER SKILLMAN: A procedure said
24 MacArthur's bounding, don't do any more work?

25 MR. BOROWSKY: That's right.

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1 MR. SCHULTZ: But, that's also combined
2 with the fact that the fuel did not fail in this
3 case?

4 MR. BOROWSKY: Well, it did, in three
5 of the ten cases, based on the ANSYS results, it
6 did fail.

7 MR. SCHULTZ: Okay.

8 MR. BOROWSKY: So, even in terms of
9 potential release of content, MacArthur Maze
10 bounded Newhall Pass because MacArthur Maze, all of
11 the scenarios -- for all the scenarios and all the
12 fuel rods were assumed to fail.

13 MR. SCHULTZ: Right.

14 MR. BOROWSKY: So, I guess in --

15 MR. SCHULTZ: So, in both cases, the
16 consequences were more severe and then this
17 demonstrates that the release potential is also
18 more severe --

19 MR. BOROWSKY: For MacArthur Maze.

20 MR. SCHULTZ: -- for MacArthur Maze?

21 MR. BOROWSKY: That's correct. That is
22 correct.

23 MEMBER BROWN: Can I ask just a simple
24 minded question? MacArthur Maze was an open
25 roadway collapse, Newhall Pass was a tunnel totally

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1 enclosed. Tons, I mean a long distance, lots and
2 lots of fuel, different variety, yet the
3 consequences in MacArthur Maze, you're saying were
4 more -- they all failed? They were more severe in
5 that?

6 That, for some reason, that just
7 doesn't -- is there a physical way to explain why
8 that -- to the simple minded person like me who's
9 not an analyst?

10 MR. BOROWSKY: Well, I think a lot of
11 it had to do with the boundary conditions for the
12 MacArthur Maze fire. Yes, it was not in a tunnel,
13 it was in an open environment.

14 But, the assumption made for the
15 MacArthur Maze analysis was that you have this
16 gasoline tanker fire, 8,000 and some gallons and
17 you're putting the package within that fully
18 engulfing fire.

19 So, the boundary conditions are much
20 different than in the Newhall Pass tunnel fire
21 where you have the fires based on the consumption
22 of the inherent fuel of the individual vehicle.

23 MEMBER BROWN: And proximity?

24 MR. BOROWSKY: And proximity of --
25 versus MacArthur Maze and Newhall Pass.

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1 CHAIRMAN BLEY: And, how important was
2 the insulation of the ComBox?

3 MR. FORT: I think -- Jim Fort, again
4 from PN&L.

5 But, I think that's the major point is
6 that in the MacArthur Maze scenario, you had that
7 blanket that was over the package. So, with the
8 internal -- with the continued heating from the
9 decay heat of the fuel inside of the package after
10 the fire combined with the cool down, it was the
11 temperatures were sustained for a much longer
12 period of time. And, actually, that peak
13 temperature for the fuel occurred in the cool down
14 period post-fire.

15 MEMBER BROWN: So, in Newhall Pass,
16 then you -- there was no collapse of the tunnel, no
17 ceiling collapse, no --

18 MR. FORT: Correct, no.

19 MR. ADKINS: It's falling.

20 MEMBER BROWN: Yes, it's falling but
21 that's relatively trivial, relative to having the
22 concrete --

23 MR. ADKINS: Right.

24 MEMBER BROWN: Okay, thank you.

25 MR. BOROWSKY: Next slide, please?

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1 So, at this point, I'd just like to
2 summarize, you know, some of the information
3 presented in the compendium and some conclusions.

4 CHAIRMAN BLEY: Can I ask one other
5 question? You put these results in terms of the A-
6 2. And, when I look at the A-2, it's a vast array
7 of radionuclides I think might be in there.

8 But, can you relate that A-2 to dose at
9 a distance from the fire or anything like that? I
10 mean, it's a real mix of curies of everything and I
11 just -- I have no idea what the hazard from that
12 is.

13 MR. BOROWSKY: Right. I guess one way
14 of -- I hope this answers your question.

15 One way of answering that is that for
16 release purposes, the dose is basically defined by
17 basically the effect of inhalation or ingestion of
18 a particular --

19 CHAIRMAN BLEY: Yes, did you do any
20 calculations like that to see what the dose is?

21 MR. BOROWSKY: No, we did not. I mean
22 we basically said, okay, Part 71.51 says that the
23 release must be limited to --

24 CHAIRMAN BLEY: A-2 in a week.

25 MR. BOROWSKY: -- an A-2 per week.

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1 PARTICIPANT: At the boundary.

2 MR. BOROWSKY: Right, right. And so,
3 we just checked and saw that, okay, since --

4 CHAIRMAN BLEY: I don't have a clue
5 about how big a deal that is, I really don't from
6 its definition.

7 MR. BOROWSKY: Right. You know, I'm
8 not a health physicist, so I hesitate to translate
9 and A-2 into an equivalent.

10 CHAIRMAN BLEY: Well, it depends on
11 lots of things. It isn't a --

12 MR. BOROWSKY: That is true.

13 CHAIRMAN BLEY: So, we didn't do any
14 calculations like that to see what these are worth?

15 MR. BOROWSKY: No.

16 CHAIRMAN BLEY: Somebody somewhere has,
17 I'm sure.

18 MR. BOROWSKY: Well, I mean NRC has.
19 The fact that --

20 CHAIRMAN BLEY: Because that's in the
21 regulations.

22 MR. BOROWSKY: -- is A-2 -- less than
23 A-2 per week means that --

24 CHAIRMAN BLEY: But, it must mean it's
25 a pretty low release, yes.

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1 MR. BOROWSKY: Right. But, what the --
2 how to translate or what to translate a .24 A-2
3 value is in terms of a dose, an internal dose
4 summary --

5 CHAIRMAN BLEY: It's like 200 nuclides
6 at various different concentrations. I mean, not
7 concentrations, various different amounts of
8 terabecquerels. Okay, thank you. I'll have to
9 look somewhere else for that.

10 MR. BOROWSKY: Just want to, again,
11 summarize some of the information presented in the
12 compendium and some of the conclusions.

13 Four case studies were analyzed such as
14 the fire duration and peak fire temperature were
15 above those of the hypothetical accident condition
16 fire defined by the regulations.

17 Again, the regulations, it's 1,475
18 degrees Fahrenheit at 30 minutes, Baltimore Tunnel
19 fire was for seven hours at 2,084 degree Fahrenheit
20 peak temperature.

21 The Caldecott Tunnel fire was 40 minute
22 duration at 1,965 degree Fahrenheit peak
23 temperature.

24 MacArthur Maze fire, there was a total
25 duration of 108 minutes, 37 minutes of that had a

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1 peak temperature of 2,012 degrees Fahrenheit and 71
2 minutes was at 1,652 degrees Fahrenheit peak
3 temperature.

4 Depending on the situation with Newhall
5 Pass, there was a three to five hour duration and
6 peak temperatures up to 1,991 degrees Fahrenheit.

7 There were a number of detailed
8 analyses performed, thermal analyses using a fire
9 dynamic simulator, COBRA-SFS and ANSYS and
10 structural analysis using the ANSYS and LS-DYNA
11 codes.

12 Next slide?

13 These case studies analyzed the
14 potential impact on spent nuclear fuel packages due
15 to severe real world fires. The four analyses have
16 shown packages are robust in their response to
17 conservative accident scenarios.

18 Dose requirement limits were met and
19 less than an A-2 quantity of potential release.

20 CHAIRMAN BLEY: It's there again and I
21 know you can't give me much more, but the
22 assumption that the seals fail, in practical terms,
23 you then -- do you then say all of the CRUD and any
24 fuel that melts comes out?

25 MR. BOROWSKY: Well, it's -- for

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1 release analyses, we used what are called release
2 fractions. So, for accident --

3 CHAIRMAN BLEY: But, there are still
4 some allowance for the mechanical small opening
5 that's there?

6 MR. BOROWSKY: Yes. Well, the short
7 answer is not all of the content -- not all of the
8 radioactive content is available for release. Only
9 a fraction --

10 CHAIRMAN BLEY: Right, but do you
11 assume all that is available comes out or only a
12 fraction of that?

13 MR. BOROWSKY: We assume that for the
14 amount that could come out, we did not take into --
15 for example, we did not take into account the fact
16 that there was potentially only a very small
17 opening between the lid and the flange.

18 CHAIRMAN BLEY: You effectively assumed
19 it was an open --

20 MR. BOROWSKY: Yes.

21 CHAIRMAN BLEY: -- open hole?

22 MR. BOROWSKY: Yes, we didn't take into
23 account --

24 CHAIRMAN BLEY: So, this A-2 quantity
25 is really a high upper bound --

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1 MR. BOROWSKY: Yes.

2 CHAIRMAN BLEY: -- of what would come
3 out?

4 MR. BOROWSKY: Yes. You know, a
5 particulate maybe you could assume 90 percent
6 settling, for example.

7 So, again, yes, less than an A-2
8 quantity of potential releases, you know, which
9 overall show that, you know, the current NRC
10 regulations and packaging standards provide a high
11 degree of protection to the public health and
12 safety.

13 And, you know, with that, you know, we
14 thank you for the meeting and, you know, want to
15 ask if there are additional questions.

16 MEMBER SKILLMAN: I would ask this
17 question. In four out of four sets of analyses
18 here, the temperatures that you predict are greater
19 than the current regulation limit, regulatory
20 limit.

21 Just from an academic perspective, why
22 wouldn't you then change the regulatory limit?

23 MR. BOROWSKY: Well, I --

24 MEMBER SKILLMAN: I can understand the
25 argument, hey, the 1,475 covered all of these, so

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1 what's the fuss? But, from an optics perspective,
2 why wouldn't you just bump it up to a number that's
3 a couple hundred degrees Fahrenheit higher?

4 MR. BOROWSKY: I think a lot of it
5 depends or can be spoken to in regards to the 1,475
6 represents a good boundary condition to represent
7 accidents.

8 The fact that there are potentially
9 severe fires out there that result in temperatures
10 higher than that doesn't necessarily point that the
11 hypothetical accident condition fires should be
12 higher. The hypothetical accident condition fire
13 doesn't necessarily represent, you know, the most
14 severe fire that's potentially out there.

15 I mean, I think the intent of the -- of
16 it is to show that with those conditions currently
17 as defined by the regulations, the package as a
18 whole is robust to survive these accidents.

19 I'm not too sure if that satisfies your
20 answer or your question.

21 MEMBER SKILLMAN: I don't want to be
22 frivolous, but I just remember this discussion from
23 over 30 years ago and the way we were thinking
24 about the TMI-2 shipments. We said our wife and
25 children are in the Interstate 95, the package is

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1 in a truck in the next lane. Will our wife and
2 children be safe, yes or no?

3 And so, I'm unfortunately stuck in that
4 paradigm and so, here I say, here are these four
5 events, in each case, the actual analyzed
6 temperature is higher than the current regulatory
7 limit. I understand your point that through the
8 analysis, the packages didn't breach or, if they
9 did, the consequences are of no real significance.
10 But, there's an optics piece.

11 So, that's my thought.

12 MEMBER RICCARDELLA: Is the
13 hypothetical accident condition something that the
14 vendors designed to with margin?

15 MR. BOROWSKY: Well --

16 MEMBER RICCARDELLA: And with safety
17 factors or something like that?

18 MR. BOROWSKY: Yes, I mean we, you
19 know, we would normally look -- basically an
20 application comes in and reviewers look at the
21 total package. And we look and see, for example,
22 how much margin is the PCT relative to the
23 allowable temperature?

24 Did the applicant use conservative
25 boundary conditions? Is the model conservative?

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1 So, you know, broadly speaking, yes,
2 there is margin within that. But, in terms of the
3 temperature -- in terms of temperature boundary
4 condition that they apply to their analysis, they
5 do use the 1,475 degree Fahrenheit value.

6 The application as a whole has
7 conservatisms.

8 MR. CHANG: Plus, we look at how the
9 model defines conservative. But, in my experience,
10 the margins for the accident is very huge. It's
11 much, much bigger 1,475 degrees. I believe at this
12 model, like a 20 percent and we feel comfortable.

13 MR. ADKINS: One of the things that I
14 think needs to kept in mind is the regs, the
15 purpose they serve is to establish a package with
16 conservatism and that it should almost be looked at
17 as like a stoutness test.

18 And then, if you look at the background
19 of that temperature itself, it's an internationally
20 accepted temperature. And, there's a lot of things
21 that feed into it all way from the '67 to '93
22 PATRAM conference proceedings that led into the
23 establishment of this temperature boundary.

24 And, what it takes into account is the
25 probability and likelihood for one, the likelihood

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1 for all these things that would compound and lead
2 to a fire of such magnitude available products to,
3 you know, start the fire, what the likelihood is
4 that it would even be -- have the potential of
5 being an engulfing fire.

6 And then, the last part is, all of the
7 things that the surrounding environment can do to
8 detract from the fire magnitude and the temperature
9 magnitude.

10 And, unfortunately, I wish I would have
11 reviewed a lot of those to establish how things
12 come back to that 1,475. But, there is a
13 substantial basis that IAEA is putting together
14 some documentation where that number comes from and
15 it is an internationally accepted standard
16 temperature.

17 MEMBER RICCARDELLA: Okay, thanks.

18 MEMBER STETKAR: You gave me an opening
19 which you shouldn't have. You mentioned the words
20 probability and likelihood. I think you used
21 probability and likelihood and I don't understand
22 that, but that's okay.

23 NRC has a policy for using risk
24 information to support regulatory decisions. I'm a
25 risk analyst, we have evidence, I'll just follow up

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1 on something Dick sort of alluded to as did Dana.

2 We have evidence now, and you've run
3 all kinds of simulations and done all kinds of fire
4 burning, but we have evidence of four events where
5 conditions could exceed our nominal design basis.

6 We have the Fukushima Nuclear Power
7 Plant where conditions, indeed, exceeded the
8 nominal design basis of that plant.

9 How do you guys account for actual
10 risk? I mean, one could do some evaluation of risk
11 in the way that we do it throughout the agency and
12 ask the question, what does this evidence tell us
13 about the frequency of events? What's the
14 likelihood that those events could cause an
15 undesired condition?

16 What's the consequences of those
17 undesired conditions in terms of health and safety
18 of the public, not looking at internationally
19 accepted values that everybody agrees to today?

20 So, have you thought about this problem
21 at all in that context given this now evidence that
22 we have? We're not talking about $10^{80\text{th}}$ per year
23 events. We actually have some evidence, we have
24 some supporting deterministic analyses, if I can
25 call them that, with ranges of assumptions applied

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1 to them.

2 MR. BOROWSKY: But, I guess I just
3 would like to follow up a little bit with that
4 comment with the idea that, yes, these are
5 accidents that occurred. But, they did not occur
6 with radioactive material.

7 So, the, you know, in terms of I guess
8 risk and probability, and I'm not an expert at
9 that, but, you know, what NRC analyzed in NUREG-
10 2125 showed that, for radioactive material
11 transport, the risks or the probability or an
12 accident is very low.

13 I guess it's very --

14 MEMBER STETKAR: But that's an accident
15 involving that particular transport vehicle, right?
16 Driving -- we're not talking about it being exposed
17 in a tunnel to a truck that catches on fire, you
18 know, a quarter of a mile away. That wasn't
19 analyzed in 2125 was it?

20 MR. ADKINS: I think 2125 and, I'm no
21 expert on this one, are brethren. Sadia is the one
22 that performed this work, but their intention was
23 to take a look at the current conditions of what
24 transport configurations could be without some of
25 the recent no pass rules and things of that nature

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1 and weigh those in and take those into account.

2 And, that was the establishment of that
3 document in particular is to identify, you know,
4 what the associated risk and the potential accident
5 frequency could be and then the probability of
6 having an accident of such magnitude.

7 CHAIRMAN BLEY: I don't know these by
8 number. Was that the study looking at
9 transportation to Yucca Mountain?

10 MR. BOROWSKY: That was the CITRA
11 report, spent fuel -- the 2125 was the spent fuel
12 transportation risk assessment NUREG.

13 CHAIRMAN BLEY: Okay.

14 MR. ADKINS: So, if you think about
15 that one, it's kind of a companion to these studies
16 that have been performed.

17 In fact, one of the things that they
18 did during their studies just to, I guess, cut to
19 the chase quicker on what the implications would be
20 regarding the accidents themselves is considered
21 probably a little more conservative boundary
22 conditions and consequences of packages being
23 involved in said accidents and still kind of
24 looking at accident frequencies on rail and road,
25 the numbers are and the frequency are substantially

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1 low.

2 And, one more point that needs to be
3 made is, when you look at the four cases that we
4 evaluated, they are super positioned. It's
5 expressed throughout each one of those evaluations
6 where we make all the fuel pool up underneath the
7 cask even though there was no cask involved.

8 And, there's the presence of buffer
9 cars and everything else. There's quite a few
10 assumptions that you need to perform to even get to
11 -- and to establish and veer away from the
12 likelihood of something like that happening. And
13 then, superimposing all these things to happen as
14 an occurrence in the same location.

15 MR. SCHULTZ: Joe, in the summary
16 discussions you have made today, in the case of
17 MacArthur Maze, you presented results of
18 metallurgical evaluations that showed what the
19 expected temperatures were in the fire situation.

20 With regard to Caldecott Tunnel and
21 Newhall Pass, is there also evidence that was used
22 to benchmark the results of the computer analyses?

23 MR. BOROWSKY: Yes, in both -- in those
24 other instances, the relevant NUREGs speak of
25 material analysis that were performed.

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1 Some of it maybe was focused more on
2 the concrete, like the fact that the concrete grid
3 is such a value in the case of certain potential
4 temperature.

5 And, I think in some of the early -- in
6 some of the NUREG/CRs that are listed in the early
7 slides, those are the -- some of them are the
8 material analyses that were performed specifically
9 for those accidents.

10 MR. ADKINS: In support.

11 MR. BOROWSKY: In support of. So, for
12 example, NUREG/CR-6799 was one and NUREG/CR-7101
13 was also.

14 MR. SCHULTZ: Great, thank you.

15 MR. CHANG: Yes, in your slide number
16 five.

17 MR. SCHULTZ: Thank you.

18 MEMBER BROWN: I have another question.
19 Throughout your presentation, you discussed about
20 releasing quantity, A-2 quantities, whereas the
21 NUREG also discussed -- it talked about Type B
22 quantities which includes spent nuclear fuel
23 materials, and yet, which are more hazardous than
24 the A-2 quantities.

25 And yet, these were exposed, your

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1 scenarios were greater than the hypothetical
2 regulations go. And, but yet, you never talked
3 about the impact on the specific subject which is
4 spent nuclear fuel type packaging. Did I miss
5 something --

6 MR. BOROWSKY: No.

7 MEMBER BROWN: -- in one of your --

8 MR. BOROWSKY: No, no, that's a good
9 point.

10 I mean, the information is included in
11 the NUREG/CRs, but you'll see, for example, I
12 believe it's MacArthur Maze, for example, in
13 Chapter 8, you'll see the inventory, the spent fuel
14 inventory, the content basically within that
15 package.

16 And, the resulting number of curies
17 associated with that and what the overall content
18 activity would be.

19 And then --

20 MEMBER BROWN: For a Type B?

21 MR. BOROWSKY: Yes.

22 MEMBER BROWN: I mean because Type B
23 has a -- according to this, it has a -- can carry
24 more than an A-2 quantity --

25 MR. BOROWSKY: That's correct.

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1 MEMBER BROWN: -- of radioactive
2 material.

3 MR. BOROWSKY: That is correct. Yes, I
4 mean, the Chapter 8, again, I'm really speaking to
5 the MacArthur Maze, but the other rates you guys
6 also mentioned, the total content inventory --

7 MEMBER BROWN: Okay.

8 MR. BOROWSKY: -- which is, you know,
9 much more than an A-2.

10 What we just presented here were the
11 back end results, you know, what could actually --
12 of that, what could get out and that's where it
13 becomes less than an A-2 quantity.

14 MR. ADKINS: I believe we even gave a
15 total of possible inventory, complete inventories,
16 to do a rudimentary comparison.

17 MR. BOROWSKY: Yes.

18 MR. ADKINS: Because one A-2 is
19 insignificant, obviously, compared to what the
20 total payload would be.

21 MEMBER BROWN: Well, the reason -- one
22 of the reasons for asking the questions, it talked
23 about the, I guess, 10 CFR 71 says in this package,
24 and if you have the hypothetical circumstance, it's
25 supposed to release less than an A-2 quantity per

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1 week.

2 Now, if these were scenarios that
3 exceeded the hypothetical scenario which would
4 imply that you could have releases greater than the
5 regulatory basis of one A-2 quantity per week. So,
6 that seemed to be a little bit of an inconsistency
7 when we draw our conclusions that everything seems
8 to be --

9 MR. BOROWSKY: I think --

10 MEMBER BROWN: But, there's not many
11 accidents that could result in this. I mean, I'm
12 not arguing with that conclusion. It's just that
13 there are circumstances under your all's scenarios
14 seems that would release more than this A-2
15 quantity. That's the point of my question.

16 MR. BOROWSKY: Okay. Again, I hope I'm
17 answering this correctly. And, maybe it's just
18 more of a semantics. What we're trying to say in
19 this presentation is, you know, the packages
20 studied, whether it's LWT or GA-4 or the others,
21 they were carrying spent fuel which has an
22 activity, an A-2 value because it's Type B, you
23 know, very high.

24 And, when we numerically placed that
25 package with that content with the high activity in

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1 it within these severe fire accident scenarios,
2 even though they are beyond the hypothetical
3 accident condition fire boundary conditions, they
4 still meet the regulatory limit. The released
5 amount, the potential release amount would still be
6 --

7 MEMBER BROWN: Less than an A-2.

8 MR. BOROWSKY: -- below A-2 per week.

9 MEMBER BROWN: Okay, I missed the
10 nuance, excuse me.

11 MR. CHANG: Yes, when we say less than
12 A-2, this means out of continuum --

13 MEMBER BROWN: I got that based on the
14 -- yes, thank you. Okay, thank you very much.

15 MEMBER SKILLMAN: Your backup slide 50,
16 please?

17 That second bullet is interesting. You
18 say when the package is cooling, the lid tightens.
19 What you don't say is when the lid is heating, the
20 lid relaxes. How come?

21 MR. BOROWSKY: Do you want me to speak
22 to this?

23 MR. ADKINS: Yes, it's probably good.

24 MR. BOROWSKY: So, one of the things
25 that we did, and I guess maybe it's just a poorly

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1 worded slide, but one of the things that we did is
2 we tracked temperature, time, real time throughout
3 the fire scenario, right, and the transients for
4 every one of these sensitivity studies.

5 And some designs are where they tighten
6 up as they get hotter, some designs not so much.
7 This particular GA-4 cask, it has HeliCoil threads
8 for key inserts that actually, unfortunately, their
9 temperature capacity is lower than the base
10 materials of the bolt and the flange itself.

11 So, one of the things that we had to do
12 as an exercise when we realized that we were
13 getting close to the temperature margin of the
14 threads itself and for the purpose of answering
15 your question, we had to do evaluations on how much
16 this would be loaded and whether it got loaded to a
17 plastic regime and then, if so, how much strain
18 hardening would occur during that loading.

19 And then, after it cools off, whether
20 it was a gap that resided between the lid and the
21 implants. Right?

22 And, this was to coincide and actually
23 led into some of the testing that was done in NIST
24 where they just bolted a flange together with no o-
25 ring and saw what kind of leak rate they could get

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1 because we knew full well that the assumption was
2 that the o-ring was going to fail straight out of
3 the gate, right, because we were far beyond its
4 service temperatures.

5 So, we ended up having to do these
6 types of analyses and figuring out what the
7 clamping force was. The net effect is the clamping
8 force in this particular instance on this cask,
9 which I believe is probably one of the weaker casks
10 in its bolting flange area, the bolted flange area,
11 is still, it -- even with this beyond regulatory
12 condition accident simulated, it's the clamping
13 force is still 80 percent after cool down. I think
14 it was like 80, 82 percent, somewhere in there.
15 So, still substantially high.

16 One of the, you know, sister studies,
17 of course, was done over at NIST. There were two
18 findings that came out of that.

19 When they tried to pressurize and have
20 a substantial leak rate with the machine finishes
21 that are provided on a lot of these flanges is they
22 could not establish a substantial leak rate.

23 And then, one that's a really important
24 key factor is, when they started their studies and
25 tests, started their tests themselves on some of

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1 the polymeric seals, they actually started the test
2 at one or a couple of hundred degrees above what
3 the service temperature was of that particular o-
4 ring material and then went up.

5 So, instantly exposed it to something
6 that it wouldn't normally be accustomed to or be
7 designed to withstand and then went up from there.

8 And the net influence was the polymeric
9 seals had a notorious tendency to flow, as we
10 talked about earlier, and actually plug the leak.
11 And that happened in a number of the cases at MIST
12 during their studies.

13 So, to get back to this, this was
14 probably poorly worded on our part and we apologize
15 for that because, ultimately, the question that you
16 probably had is, well, does it leak? Is there a
17 gap? Is there compromise of that bolted closure
18 after it cools down or during the thermal
19 excursion? The answer is no.

20 Hopefully that answered that.

21 MEMBER SKILLMAN: That was my question.
22 Thank you.

23 MR. BOROWSKY: Okay, you bet.

24 CHAIRMAN BLEY: Any more questions from
25 the members? Chris, can we get the phone line

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1 open?

2 While we're waiting to open the phone
3 line -- I'm sorry, yes?

4 MR. BOROWSKY: I just wanted to mention
5 something. We were talking in the hallway during
6 the break and I just wanted to clarify a comment
7 about the TN-68 impact limiters.

8 CHAIRMAN BLEY: Yes, go ahead.

9 MR. ADKINS: I misspoke. So, one of
10 the things that we did is, you know, there's this
11 assumption of what kind of conditions these
12 packages reside in and, you know, if you don't have
13 an impact of the package like where we're
14 superimposing, the fuel rushes over and lights up
15 underneath.

16 We did a couple of different
17 evaluations and it was through the course of
18 actually building the model, and so I need to
19 correct, on the TN-68, as our final analysis, what
20 we did is we kept the wood material in its pristine
21 state so it would have its highest conductivity
22 state, bringing heat into the cask and then
23 directly at the point of cessation turned it into
24 charcoal so the conductivity would be muted.

25 And, the reason being is, as you get

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1 the burn front and the consumption front of the
2 wood as it migrates to the interior, what you end
3 up with is, you know, like a charcoal type state,
4 but also a boundary that becomes more radiative,
5 inner exchange in nature, you know, comprised of
6 almost exclusively radiation because you don't have
7 as it burns back until there's a substantial amount
8 of material. You don't have a void or a volume
9 that's large enough to support substantial
10 convection.

11 So, that is a clarification for that
12 analysis. That was the end state analysis. And,
13 the reason being were for two things, there wasn't
14 a compelling reason the impact limiter would gone
15 and the other one was there was no confirming
16 reason that there would be substantial damage to
17 the impact limiter, especially when you look at
18 some of these cases where we tried to superimpose
19 and put the cask at any location within the tunnel
20 that would subject it to the most thermal insult.

21 Does that make sense?

22 MEMBER SKILLMAN: Well, it does, but I
23 think you've changed the tone of your answer. I'm
24 the one who asked the question the use of the
25 impact limiters are assumed to not be there.

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1 MR. ADKINS: That's correct.

2 MEMBER SKILLMAN: Therefore, we've got
3 full flow heat onto both ends.

4 MR. ADKINS: That's correct.

5 MEMBER SKILLMAN: What you just said is
6 --

7 MR. ADKINS: That's not, yes.

8 MEMBER SKILLMAN: -- with the impact
9 limiters there, there is a different thermal
10 conductivity and convection thermodynamic
11 occurring.

12 MR. ADKINS: You are correct, that's
13 correct.

14 MR. BOROWSKY: And, that was for the
15 TN-68, but for the MacArthur Maze analysis, there
16 were two analyses studied, one with the impact
17 limiter and one without the impact limiter.

18 So, it wasn't a TN-68 that didn't have
19 the impact limiter not modeled, it was the GA-4 in
20 MacArthur Maze that also -- where we also did an
21 analyses without the impact limiter.

22 MR. ADKINS: And, I was confused. I
23 forgot the details of this because it has been
24 quite some time since we did Baltimore. It was
25 over ten years ago.

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1 But, the one point being made is, when
2 you look at something that has substantially lower
3 thermal inertia like those playing out, the NAC-
4 LWT, it only holds one fuel assembly, GA-4 only
5 holds four.

6 Each one of these fuel assemblies have
7 -- they weigh 1,550 pounds of uranium and cladding
8 material and, you know, upper and lower tie plates
9 and things of that nature. So, essentially, the
10 heat up, regardless of what it's being exposed to,
11 unless you have a dramatically higher temperature
12 difference, you can only drive so much heat into a
13 cask.

14 So, we think we've bounded it with a
15 smaller scale cask.

16 MEMBER SKILLMAN: Thank you.

17 CHAIRMAN BLEY: Thank you.

18 The phone is obviously open. If
19 there's anyone on the phone line who would like to
20 make a comment, now is the time. Please announce
21 your name and give us your comment.

22 MS. GILMORE: This is Donna Gilmore in
23 California.

24 CHAIRMAN BLEY: Hello.

25 MS. GILMORE: My question is, in terms

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1 of the assumptions, I know the welded canisters,
2 you have no way to inspect what condition the
3 baskets are in and recently, Pepco inspected a
4 Fukushima aluminum basket and found they didn't
5 think it would last more than 40 years.

6 So, I'm just wondering if there was any
7 assumptions made about the integrity of the baskets
8 considering you can't inspect those at all in the
9 welded canisters, anyway?

10 CHAIRMAN BLEY: Thanks.

11 This is just information gathering for
12 the committee at this time, but we will certainly
13 consider your question as a comment, something for
14 us to consider.

15 Does anyone else have a comment or do
16 you have any further comments?

17 MS. GILMORE: Yes, in terms of
18 transport, currently the thin canisters cannot be
19 inspected for cracks. So, I don't know the
20 assumption, whether the canister had full integrity
21 as required by NRC regs. So, I just that -- I'm
22 hoping that issue gets addressed.

23 CHAIRMAN BLEY: Okay. Thank you very
24 much.

25 I would note that the NRC reports, reg

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1 reports, for all of these analyses are publically
2 available on the NRC website now.

3 Is any other comments from the phone
4 line?

5 MR. HOFFMAN: Hi, this Dave Hoffman.

6 CHAIRMAN BLEY: Please go ahead.

7 MR. HOFFMAN: Thank you.

8 I wanted to comment on the, let's see,
9 the hypothetical condition fire and some of the
10 other hypothetical conditions seem to be of not --
11 they are not a design that includes the accidents
12 that were even discussed during this hearing.

13 And, it sounded like the person who
14 said that they were designing with margin. One
15 person asked if there was a design with margin and
16 the person that answered seemed to give a very
17 circular answer that says that the NRC and the
18 industry do, in fact, rely on margin. And, I would
19 think the NRC would be the last organization that
20 would be allowed to rely on a margin above their
21 regulations.

22 So, that scares me quite a bit to be
23 hearing that.

24 And then, likewise, the concept of
25 probability and likelihood just bothers the heck

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1 out of me especially when it sounded like if a
2 bridge girder were to -- an entire bridge assembly
3 were to fall on one of these casks, you're assuming
4 there'll be a very tiny leak. And, I would think
5 there would be a full breach in that case. And,
6 I'm wondering what causes the difference.

7 And, that's all I have for today.
8 Thank you very much.

9 CHAIRMAN BLEY: Thank you very much.

10 Anyone else on the phone line care to
11 make a comment? We'll take these under
12 consideration. We'll close the phone line now.
13 There were no people in the room who wanted to make
14 comments.

15 At this time, I'm going to poll the
16 members for any closing comments they'd like to
17 make.

18 Charlie?

19 MEMBER BROWN: I have no more comments.

20 CHAIRMAN BLEY: Ron?

21 MEMBER BALLINGER: No more comments.

22 CHAIRMAN BLEY: Pete?

23 MEMBER RICCARDELLA: I have no
24 comments.

25 CHAIRMAN BLEY: Harold?

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1 MEMBER RAY: No.

2 CHAIRMAN BLEY: Dick?

3 MEMBER SKILLMAN: No more, thank you.

4 CHAIRMAN BLEY: Dana?

5 MEMBER POWERS: Well, I think the
6 studies probably accomplished what they wanted to
7 be. What I have -- what I find distressing is
8 these are the kinds of calculations that were done
9 25 years ago for the reactors. They are
10 deterministic calculations done with hodgepodes of
11 things that people suspect are bounding in some
12 sense for some purpose.

13 And, we've found the failure in that
14 kind of mode because, often times, we have
15 conflicting safety objectives where bounding
16 assumptions in one regard are not bounding in
17 other. And, we've abandoned that and gone to more
18 realistic calculations for propagations of
19 uncertainty ranges through the analyses.

20 And, it just strikes me that these are
21 throwbacks to a previous era and in calculational
22 analysis. And, I think we've found enough flaws in
23 that kind of approach within the reactor community
24 that we've been forced to abandon it and I think we
25 ought to come into the 21st Century and abandon it

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1 here as well.

2 CHAIRMAN BLEY: Thank you.

3 Mr. Stetkar?

4 MEMBER STETKAR: I don't have anything
5 to add, but I agree with Dana fully.

6 CHAIRMAN BLEY: And, our consultant,
7 Steve Schultz? You'll send us a report, I assume,
8 but if there's anything you'd like to say now, we
9 will appreciate it.

10 MR. SCHULTZ: Nothing further.

11 CHAIRMAN BLEY: Thanks, Steve.

12 I have nothing more to add but I really
13 appreciate that you came to us today and presented
14 this work. We've been interested in it for some
15 time, so we're pleased you were here.

16 Thanks very much and, at this point, we
17 will adjourn this meeting so we can start the next
18 one very soon.

19 (Whereupon, the above-entitled matter
20 went off the record at 11:41 a.m.)

21

22

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A Compendium of Spent Fuel Transportation Package Response Analyses to Severe Fire Accident Scenarios

Jimmy Chang and Joseph Borowsky
Containment, Structural, and Thermal Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
March 2, 2016

NMSS

Division of Spent Fuel Management

- Motivation for Severe Fire Studies
- Regulatory Requirements for Transport of Spent Nuclear Fuel (SNF)
 - 10 CFR Part 71 Subpart F
 - 71.71** Normal Conditions of Transport (NCT)
 - used as initial condition for accident conditions
 - 71.73** Hypothetical Accident Conditions (HAC)
 - regulatory fire is 1475°F (800°C) for 30 minutes
- Fire Scenarios and Consequences for SNF Packages
- Conclusions

Severe Fire Topics of Study

- NRC recognizes that some real-world fires may exceed conditions of the regulatory fire and investigated how spent fuel transportation packages would perform in those fires.
- National Academy of Sciences (NAS) study in 2006 recommended additional emphasis on severe fire studies

“The committee recommends that the U.S. Nuclear Regulatory Commission (USNRC) undertake additional analyses of very long-duration fire scenarios that bound expected real world accident conditions.”

- *From Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States*, National Academy of Press, 2006

Severe Fire Topics of Study

- NRC has conducted fire studies to understand:
 - Types and quantities of fuel available in actual fires
 - Possible ranges of temperatures in realistic and idealized fires
 - Duration of fire in real accidents
 - Effect on packages (size and mass of the package)
 - Behavior of important-to-safety components during fire
 - Additional actions, if any, that may be needed to address real-world fire accidents

Completed Investigations

NRC worked with PNNL, NIST and CNWRA to perform numerous analyses and studies, including

- Rail car components to a tunnel fire (NUREG/CR-6799, 2003)
- Rail accident database review (NUREG/CR-7034, 2011)
- Roadway accident database review (NUREG/CR-7035, 2011)
- Structural material analysis reports (NUREG/CR-7101, 2007)
- Testing O-ring materials at high temperatures (NUREG/CR-7115, 2015)
- Baltimore Tunnel fire scenario – railway (NUREG/CR-6886, 2009)*
- Caldecott Tunnel fire scenario – roadway (NUREG/CR-6894, 2007)*
- MacArthur Maze fire scenario – roadway (NUREG/CR-7206, 2015)*
- Newhall Pass fire scenario – roadway (NUREG/CR-7207, 2015)*

*** None of these fire accidents involved radioactive materials**

Railway Fire Accidents

Railway Fire Accidents

Potential for higher temperature and longer duration fires

Environment	Rail Bed Material	Pool formation	Oven Effect	Space Restriction	Oxygen Supply
Open Fire	Porous substrate	less	no	less	more
Tunnel Fire	Rock, concrete, pavement	more	more	more	less

Fire accidents can be more severe in tunnels than in open environment

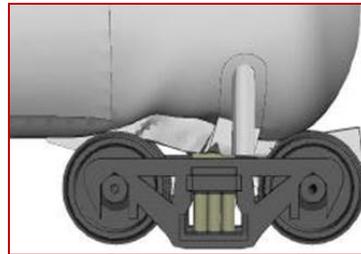
Baltimore Tunnel Fire Scenario

(Howard Street Tunnel Fire, Baltimore, 2001)

Baltimore Tunnel Fire

CSX Freight Train Derailment (single track tunnel)

- Train carrying flammable material, including HAZMAT (not SNF) derailed; tank car carrying liquid tripropylene punctured by brake mechanism; flammable liquid formed a large pool on tunnel floor
- Ignition of spilled liquid tripropylene led to severe fire lasting ~3 hours (as estimated by NTSB investigators)
- Conservative modeling of fire predicted that if fully oxygenated, the fire could have lasted ~7 hrs with peak gas temperatures of 2084°F in flame region and 1958°F at 66 ft downstream of the fire (> 1475°F fire defined in Part 71)



Baltimore Tunnel Fire

Analysis of Fire Accident Scenario

NIST FDS (Fire Dynamics Simulator) → COBRA-SFS (PNNL)/ANSYS

Used to predict fire conditions in the tunnel and provide tunnel fire boundary conditions to COBRA-SFS and ANSYS models for thermal analysis of SNF transportation packages

Conservative assumptions –

- Fire fully oxygenated, burned until entire fuel supply fully consumed.
- Peak gas temperatures (T) in tunnel zones as boundary conditions (BCs) for thermal model.
- Peak surface T on tunnel floor/walls/ceiling as BCs for thermal model.

Baltimore Tunnel Fire

Analysis of Fire Accident Scenario, cont.

COBRA-SFS (PNNL) and ANSYS (thermal models) –

Predict transient thermal response of the package during fire and extended post-fire cooldown.

Conservative Assumptions

- Rail car and package support structure are neglected to allow maximum heat transfer into the package during the fire.
- Forced convection in fire and natural convection in post-fire cooldown.
- Impact limiter & neutron shield retain nominal properties during fire and degrade in the post-fire cooldown.
- Maximum design basis heat load is used for the packages.

Baltimore Tunnel Fire

Accident Scenario Analysis Results

Package	TN-68 (large)	HI-STAR 100 (large)	NAC-LWT (small)
Peak cladding temperature (PCT)	< 1058°F	< 1058°F	< 1058°F
Peak temperature Lead gamma shield	NA	NA	> 622°F

- ❖ 1058°F (570°C) - limit of fuel cladding
- ❖ 622°F (328°C) - lead melting temperature
- ❖ Packages with **loss of neutron shield** in the fire still meet dose limit requirements

Baltimore Tunnel Fire

Accident Scenario Analysis Results, cont.

Seals	TN-68	HI-STAR 100	NAC-LWT	
Locations	Closure Port	Lid/Drain/ Vent Ports	Lid	Drain/Vent Ports
Max. Seal Temperature vs. Limit	Helicoflex > 536°F (limit)	Metallic < 1200°F (limit)	Metallic & Teflon > 800°F (limit)	Teflon > 735°F (limit)

TN-68 and NAC-LWT have maximum seal temperatures above seal material thermal performance limits. Therefore, there is potential for radioactive release from these packages

Baltimore Tunnel Fire

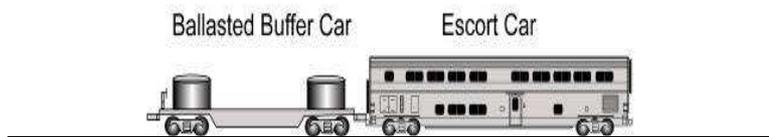
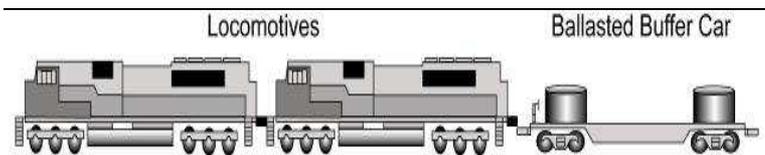
Accident Scenario Consequences

- Failure of neutron shielding is not an issue; all three packages meet regulatory requirements for accident conditions (including HAC fire) assuming loss of neutron shielding as design basis.
- No fuel rod cladding failure predicted in this tunnel fire, so no release of spent fuel particulate or fission gases
- For packages with failed seals, potential release due to Chalk River Unknown Deposit (CRUD) detaching from fuel rods less than A_2 quantity.
- No loss of gamma shielding for TN-68 or HI-STAR100 in this severe fire scenario.
- Lead melting in NAC-LWT not severe enough to lead to loss of gamma shielding; and no dose consequence.

SNF packages survive the severe rail fire with fuel integrity maintained and radiation dose below regulatory limit.

Safety of Spent Fuel Packages Shipped by Rail

- Robustness of the design (the focus of 10CFR Part 71)
- Transportation elements associated with DOT regulations, 10 CFR Part 73.37, and administrative controls.



- ✓ **DOT 49 CFR 174.85:** Requirement of buffer car
- ✓ **AAR OT-55:** no-pass rule - limit 2-track tunnel to single SNF train
- ✓ **AAR S-2043:** design standard ballasted cask cars, buffer cars, and escort car
- ✓ **Preplan and coordinate shipments**

Conclusions

- Packages evaluated are shown to be extremely robust in response to a real-world railway fire of significantly longer duration and higher peak temperatures than the HAC fire.
- Current NRC regulations and packaging standards provide a high degree of protection to the public health and safety against releases of radioactive material during real-world railway transportation accidents

Roadway Fire Accidents

Caldecott Tunnel Fire Scenario
MacArthur Maze Fire Scenario
Newhall Pass Tunnel Fire Scenario

Caldecott Tunnel Fire

State Route 24 near Oakland, CA, 1982

- Tanker truck and trailer overturned and caught fire in tunnel
- Tank trailer cargo: 8,800 gallons gasoline
- Fire duration (based on NTSB investigation):
 - Overall duration: 2.7 hours
 - Intense fire duration: 40 minutes



Caldecott Tunnel Fire

Analysis of Fire Accident Scenario

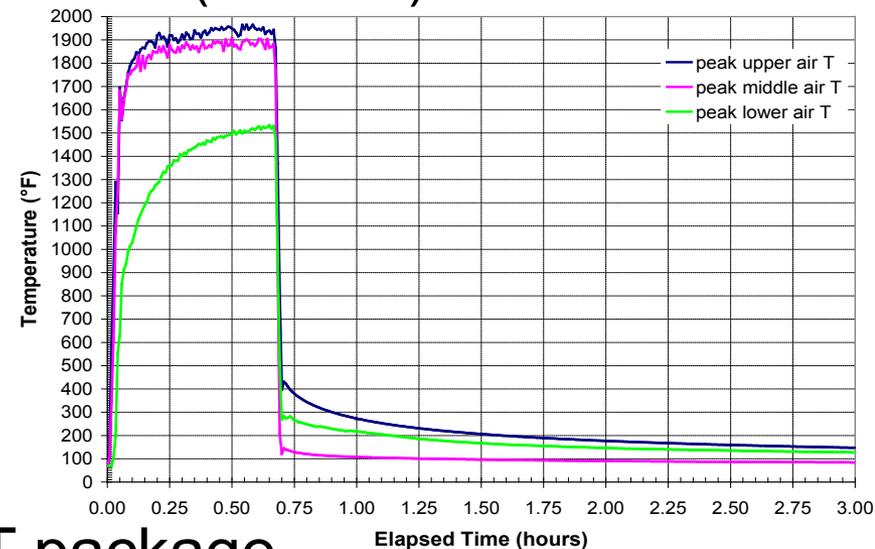
- Analysis Methodology
 - NIST's Fire Dynamics Simulator (FDS) code to determine thermal boundary conditions
 - ANSYS FEA thermal evaluations of NAC-LWT
- Model conservatisms
 - Use peak tunnel temperatures even if the package surface could not see that particular tunnel location
 - Neglect thermal shielding effect of the cradle and package conveyance

Caldecott Tunnel Fire

Accident Scenario Analysis Results

- Fire Dynamics Simulator code (NIST)
 - Maximum gas temperature: 1965°F (1074°C)
 - Fire Duration: ~ 40 minutes

Tunnel air temperature histories
Fig. 5.12 of NUREG/CR-7209



- ANSYS thermal analyses of LWT package
 - Peak cladding temperature: 544°F (284°C)
 - Peak O-ring temperature: 1288°F (698°C)
 - Gamma shield temperature: 622°F (328°C)

MacArthur Maze Fire Scenario

MacArthur Maze Fire

I-880 Connector of MacArthur Maze Interchange Oakland, CA, 2007

- Tanker truck and trailer overturned and caught fire on I-880
- Tank trailer cargo: 8,600 gallons of gasoline
- I-580 roadway located above the fire
- Intense fire weakened steel girders, collapsing two spans onto tanker
 - Enclosure formed by collapsing roadway
 - Opening sufficient for combustion airflow



Spans of I-580 collapsed onto
tanker fire on I-880



Analysis of Fire

- Analysis with Fire Dynamics Simulator code (NIST)
 - Pre-collapse fire duration: 37 minutes
 - Fully engulfing fire with uniform flame temperature of 2012°F (1100°C)
 - Post-collapse fire duration: 71 minutes
 - 1652 °F (900°C) flame temperature
- Metallurgical Analysis
 - Steel girder: 1652°F (900°C)
 - Truck radiator: 1328°F (720°C)
 - Truck engine bolt: 1657°F (903°C)



MacArthur Maze Fire

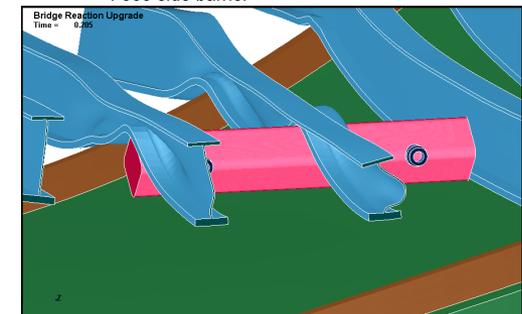
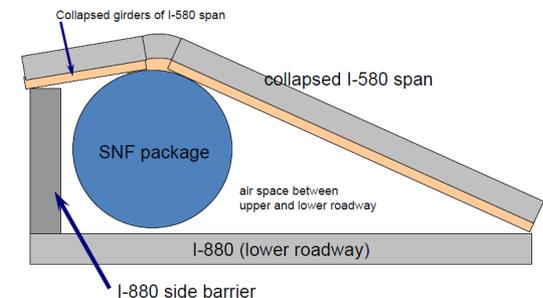
Fire Accident Scenario

- Aspects of fire scenario that are more severe than hypothetical accident condition fire (800°C and 30 minute duration, per 10CFR 71.73)
 - Pre-collapse fire: higher temperature and longer duration (1100°C for 37 minutes)
 - Post-collapse fire: higher temperature and much longer duration (900°C for 71 minutes)
 - Impact of free falling overhead span on package
 - Post fire cooldown with package assumed covered by concrete “blanket”
- Package location in most adverse location during each stage
 - On roadway in fully engulfing fire for pre- and post-collapse fires
 - Impact location and orientation determined by analysis of multiple cases
 - Under concrete “blanket” for extent of post-fire cooldown
- Analysis Methodology
 - Fire Dynamics Simulator (FDS) code for thermal boundary conditions
 - COBRA-SFS (PNNL) and ANSYS FEA thermal evaluations of General Atomics GA-4 LWT package
 - LS-DYNA to model the effect of the falling I-580 overpass

MacArthur Maze Fire

Accident Scenario Analysis Results

- COBRA-SFS (PNNL) and ANSYS thermal analyses of package
 - Pre-collapse of I-580 span (37 minutes)
 - Peak cladding temperature: 1020°F
 - O-ring temperature: 250°F
 - Gamma shield: 1250°F
 - Post-collapse of I-580 span (71 minutes)
 - Peak cladding temperature: 1425°F
 - O-ring temperature: 770°F
 - Gamma shield: 1490°F
 - Post-fire cooldown
 - Peak cladding temperature: 1400°F
 - O-ring temperature : 1150°F
- ANSYS thermal model of I-580 span
 - Steel girders of I-580 at 1800°F for impact analysis
- LS-DYNA structural/impact model of I-580 span
 - Model the effect of the falling I-580 overpass on package
 - Four impact orientations were considered
 - Local plastic strain at package outer wall
 - No gross failure or rupture of package



NUREG/CR-7206

Newhall Pass Tunnel Fire Scenario

Newhall Pass Fire

I-5 Truck Route Underpass Tunnel Los Angeles, CA, 2007

- Chain reaction traffic collision of 33 tractor-trailer trucks
 - Fire started near the tunnel exit and spread full length of the tunnel
- Twenty-four tractor-trailer vehicles were destroyed (none carrying hazardous material)
 - Combustible material: diesel (in truck tanks), tires, sheet aluminum of semi-trailers, wood, cotton, sugar, cardboard containers, fruit and vegetables
- Fire duration (for intense fire within tunnel):
 - Estimated as between 3 and 5 hours; local fires on individual vehicles estimated as 0.5 to 1.0 hours, as fire spread through tunnel



Location of fire in
truck route tunnel

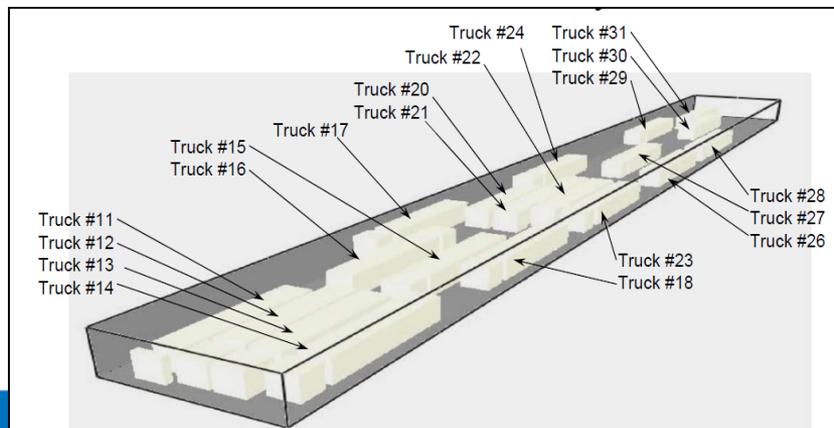
Newhall Pass Fire

Fire Accident Analysis

- Fire Dynamics Simulator Analysis (NIST)
 - Fuel budget established for each vehicle
 - Six cases considered
 - Slow and fast burn rates
 - Range of fire spread rates
 - Variation in fuel budget



NUREG/CR-7207



Newhall Pass Fire

Fire Accident Scenario

- Aspects that are potentially more severe than hypothetical accident condition fire (800°C and 30 minute duration, per 10 CFR 71.73)
 - Peak fire temperatures (854 °C – 1088 °C)
 - Local fire duration at specific truck locations range from 26 minutes to approximately 68 minutes
 - Preheating of package depending on location in tunnel
- Determine most adverse condition from a matrix of cases
 - Six fire cases developed with FDS
 - Two package locations
 - Hottest fire location (middle of tunnel)
 - Longest (preheating) fire location (just past tunnel entrance)
- Perform thermal analysis of GA-4 package for each case
 - ANSYS
 - COBRA-SFS (PNNL)

- Model conservatisms
 - Conservative combustible mass for each vehicle within tunnel
 - Assumed the entire combustible mass of each vehicle was fully consumed by fire
 - Assume fully engulfing fire at peak local temperature from Fire Dynamics Simulator code
 - Neglect thermal shielding effect of the package conveyance

Accident Scenario Analysis Results

- **COBRA-SFS** and ANSYS thermal analyses of GA-4 package
 - Longest (pre-heating) fire location
 - 64 minute local fire duration
 - Peak cladding temperature: 1020°F/834°F
 - Lid seal peak temperature of 649°F
 - Hottest fire location
 - 78 minute local fire duration
 - Peak cladding temperature: 1217°F/994°F
 - Lid seal peak temperature: 545°F

Roadway Fire Accidents - Consequences

- Caldecott Tunnel Fire Scenario
- MacArthur Maze Fire Scenario
- Newhall Pass Tunnel Fire Scenario

Caldecott Tunnel Fire Accident Scenario

Consequences for NAC LWT

- Neutron shield
 - Neutron shield is assumed lost as a result of the fire hypothetical accident condition; dose within regulatory limits
 - This is a design basis assumption, satisfied by all packages studied
- Gamma shield
 - Lead reaches melting point 23 to 34 minutes after the start of the 40 minute fire
 - Localized melting, which would still provide shielding
- Metallic lid seal
 - Peak temperatures (735/794°F with and w/o ISO container) are below 800°F continuous use limit
- Cladding
 - Peak fuel cladding temperatures (544°F with and 535°F w/o ISO container) are well below limits

- Vent/Drain Port O-Ring seals
 - Peak temperatures in seal region (1035/1288°F with and w/o ISO container) exceed continuous-use limit of TFE (735°F) and Viton (550°F) seals
 - Seals conservatively assumed to have failed
- Potential release through failed seals
 - CRUD particles from exterior of the cladding: 0.01 Curies
 - 0.01 Curies translates to 0.001 A₂ quantity, which is below the regulatory limit of an A₂/week

MacArthur Maze Fire Accident Scenario

Consequences for GA-4

- Gamma shield
 - Peak temperature of 1480°F remains well below the melting temperature of 2070°F for depleted uranium
- O-ring seals
 - Based on ANSYS results, peak temperatures of the cask lid O-ring (1160°F), drain valve seal (1170°F), and gas sample port seal (1130°F) exceed the continuous-use temperature limit of EPDM seals (302°F)
 - Analyses assumed seal failure
- Fuel cladding
 - The peak cladding temperature is predicted with both ANSYS and COBRA-SFS to reach nearly 1400°F during post-fire cooldown
 - This temperature exceeds short-term and estimated burst temperature limits

MacArthur Maze Fire Accident Scenario

Consequences for GA-4

- Closer look at potential for fuel failure
 - Used FRAPCON-DATING and FRAPTRAN fuel performance codes to predict cladding behavior
 - FRAPCON-DATING relies on creep rupture models
 - FRAPTRAN relies on burst rupture models
 - Both models predict fuel failure

LOCA Burst Strain Model (FRAPTRAN)		Creep Rupture Model (FRAPCON/DATING)	
Cladding Temperature	Rupture Conditions	Cladding Temperature	Rupture Conditions
1,097°F (592°C)	rod rupture in end region	1,229°F (665°C)	rod rupture near end

Consequences for GA-4

- Estimate of potential release
 - Release model based on pressure in package and leakage between lid and flange for the lid clamping force
 - Potential release includes
 - Fission products and spent fuel particles
 - CRUD particles assumed to have spalled from the cladding surface
 - Total release calculated: 0.24 A2 quantity, which is below the regulatory limit of an A2/week
 - Conservatively neglects particulate settling
 - Conservatively assumes no restriction on size of particles passing through small gap

Newhall Pass Fire Accident Scenario

Consequences for GA-4

- Gamma shield
 - Peak temperature of 1200°F remains well below the melting temperature of 2070°F for depleted uranium
- O-ring seals
 - Based on ANSYS results, peak temperatures of the cask lid O-ring (668°F), drain valve seal (678°F), and gas sample port seal (562°F) exceed the continuous-use temperature limit of EPDM seals (302°F)
 - Analyses assumed seal failure

Newhall Pass Fire Accident Scenario

Consequences for GA-4

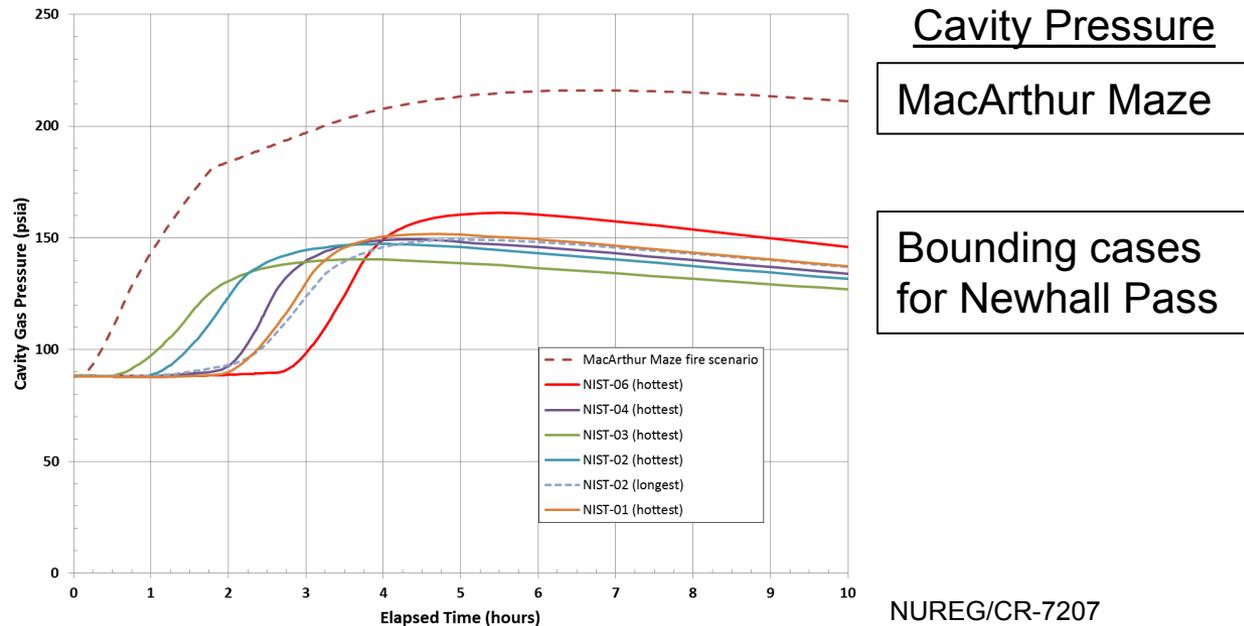
- Fuel cladding
 - The peak cladding temperatures predicted with ANSYS generally higher than COBRA-SFS for each case
 - Used input from COBRA-SFS and ANSYS for the fuel performance codes
 - FRAPCON-DATING predicted no fuel failure
 - FRAPTRAN predicted no fuel failure based on the COBRA-SFS results
 - Potential for fuel failure in three of the 10 analyzed cases based on the ANSYS thermal results
- O-Ring seal failure allows potential for release of CRUD particles that are on the exterior of the cladding



Newhall Pass Fire Accident Scenario

Consequences for GA-4

- MacArthur Maze fire scenario conditions bounded the Newhall Pass Tunnel fire scenario conditions



- Therefore, consequences were conservatively assumed to be the same as for the MacArthur Maze fire scenario

Summary and Conclusions

- Case studies of severe fires
 - Baltimore Tunnel fire: 7 hour duration, 2084 °F peak temperature
 - Caldecott Tunnel fire: 40 minute duration, 1965 °F peak temperature
 - MacArthur Maze fire:
 - Pre-collapse fire: 37 minute duration, 2012 °F peak temperature
 - Post-collapse fire: 71 minute duration, 1652 °F peak temperature
 - Newhall Pass Tunnel fire:
 - 3 to 5 hour duration, peak temperatures up to 1991 °F
- Detailed analyses
 - Thermal analyses (FDS, COBRA-SFS, ANSYS)
 - Structural analyses (ANSYS, LS-DYNA)

Summary and Conclusions

- Case studies analyzed the potential impact on spent nuclear fuel packages due to severe real-world fires
- The four analyses have shown packages are robust in their response to conservative accident scenarios:
 - Dose requirement limits were met
 - Less than an A_2 quantity of potential releases
- Current NRC regulations and packaging standards provide a high degree of protection to the public health and safety