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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

492ND MEETING

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THURSDAY, MAY 2, 2002

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ROCKVILLE, MARYLAND

The ACRS met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., George E. Apostolakis, Chairman, presiding.

COMMITTEE MEMBERS:

GEORGE E. APOSTOLAKIS	Chairman
MARIO V. BONACA	Vice Chairman
F. PETER FORD	Member
THOMAS S. KRESS	Member-at-Large
GRAHAM M. LEITCH	Member
DANA A. POWERS	Member
VICTOR H. RANSOM	Member
STEPHEN L. ROSEN	Member
WILLIAM J. SHACK	Member
JOHN D. SIEBER	Member
GRAHAM B. WALLIS	Member

ACRS STAFF PRESENT:

JOHN T. LARKINS	Executive Director, ACRS/ACNW Designated Government Official
SHER BAHADUR	Associate Director, ACRS/ACNW
HOWARD J. LARSON	Special Assistant, ACRS/ACNW
SAM DURAISWAMY	Technical Assistant, ACRS/ACNW
PAUL A. BOEHNERT	

ALSO PRESENT:

ZENA ABDULLAHI	NRR
TONY ATTARD	NRR
GOUTAM BAGELI	NRR
S. SINGH BAYWA	NRR
HERB BERKOW	NRR
TAMMY BLOOMER	NRR
RALPH CARUSO	NRR
ED CONNECE	NRR
RICHARD ECKENRODE	NRR
RAJ GORJ	NRR
JOHN GOSHEN	NRR
DONNIE HARRISON	NRR
GARY HOLAHAN	NRR
T.W. C. HUG	NRR
EDWARD D. KENDRICK	NRR
RALPH LANDRY	NRR

ALSO PRESENT: (Cont'd)

RICHARD LOBEL	NRR
KAMAL MANOLY	NRR
L.B. (TAD) MARSH	NRR
RALPH MEYER	NRR
BRENDA MOZAFARI	NRR
YURI ORECHWA	NRR
K. PARCZEWSKI	NRR
ANNE PASSARELLI	NRR
ROBERT PETTUS	NRR
J.H. RAVAL	NRR
THOMAS SCARBROUGH	NRR
HERALD SCOTT	NRR
MOHAMMED SHUMBI	NRR
DAVID TERAD	NRR
D. THATCHER	NRR
N.K. TREHAN	NRR
S.D. WEERAKKODY	NRR
ERIC WEISS	NRR
JARED WERMIEL	NRR
JIM WIGGINTON	NRR
ALAN LEVIN	OCM/RAM
FAROUK ELTAWILA	RES
JOCELYN MITCHELL	RES
JASON SCHAPEROW	RES

ALSO PRESENT: (Cont'd)

CHARLES TINKLER	RES
LEONARD R. BELLER	Progress Energy, CP&L
TOM DRESSER	Progress Energy, CP&L
PAUL FLADOS	Progress Energy, CP&L
C.J. GANNON	Progress Energy, CP&L
MARK GRANTHAM	Progress Energy, CP&L
ROBERT KITCHEN	Progress Energy, CP&L
MARK A. TURKAL	Progress Energy, CP&L
MICHAEL S. WILLIAMS	Progress Energy, CP&L
BLANE WILTON	Progress Energy, CP&L
FRAN BULGER	GE Nuclear Energy
CARL HINDS	GE Nuclear Energy
DAN PAPPONE	GE Nuclear Energy
JASON POST	GE Nuclear Energy
GEORGE STRAMBACK	GE Nuclear Energy
CHARLES BRINKMAN	Westinghouse Electric Company
WILLIAM SLAGLE	Westinghouse Electric Company
PETER HASTINGS	DCS
LAWRENCE LEE	ERIN Engineering
JAMES F. MALLAY	Framatome ANP
JOE MIHALCIK	Constellation Energy Group/EPRI

I-N-D-E-X

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

8:32 a.m.

CHAIRMAN APOSTOLAKIS: The meeting will now come to order. This is the first day of the 492nd meeting of the Advisory Committee on Reactor Safeguards. In today's meeting, the Committee will consider the following: Brunswick Steam Electric Plant, Units 1 and 2 Core Power Uprate, Expert Panel Recommendations on Source Term for High Burnup and Mixed Oxide Fuel, Confirmatory Research Program on High Burnup Fuel, Subcommittee Report regarding MOX Fuel Fabrication Facility, Safeguards and Security Activities, Proposed ACRS Reports.

A portion of the meeting will be closed to discuss General Electric proprietary information applicable to the Brunswick Plant core power uprate. the entire session on safeguards and security activities will be closed to protect national security information and safeguards information. This session will be held in T8E8.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Dr. John Larkins is a designated federal official for the initial portion of the meeting. We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions.

A transcript of portions of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

I have a short announcement before we start. Mr. Jit Singh, stand up, please. He's leaving us. He'll be joining the Office of Nuclear Regulatory Research as a Senior Reliability and Risk Analysis Engineer in the Division of Risk Analysis and Applications, and this will be effective May 6, which is next Monday.

As we all know, Jit has provided very valuable service to this Committee for seven years, about seven years, especially in the area of fire protection. And there will be a farewell luncheon in the Subcommittee Room tomorrow at lunchtime. That's when usually luncheons are held. And we are all invited. That's my understanding. Is that correct, Jit? Okay. We wish you well.

(Applause.)

Okay. The first item on the agenda is the Brunswick core power uprate, and Professor Wallis is the cognizant member. Please.

MR. WALLIS: Good morning.

CHAIRMAN APOSTOLAKIS: Good morning.

MR. WALLIS: This is a power uprate of a BWR to roughly 20 percent above its original power level. It's very much like what we've seen before with Duane Arnold, Dresden and Clinton, and I think it needs no more introduction from me.

MR. KITCHEN: Good morning.

MR. FORD: Excuse me. I'd like to declare a conflict of interest being a GE retiree.

MR. RANSOM: And I have to declare a conflict of interest because I still haven't sold my GE stock, but I'll get rid of it shortly.

MR. WALLIS: I'll give you ten bucks a share.

(Laughter.)

MR. KITCHEN: Good morning. My name is Bob Kitchen. I'm the Project Manager for the power uprate at the Brunswick Station. I'd like to take a few minutes and just talk to you about the project in total and a few items for the overview, also to give you a reference of where Brunswick is today relative to where we're trying to go.

Currently, we -- we previously had done a stretch uprate, which is a five percent increase in power above the original licensed power level. So we currently operate at 105 percent relative to original power. We're also a two-year operating cycle, 24 months, which I think we are the first licensee for the ACRS review that is a two-year fuel cycle. Our increase is actually to raise power to 120 percent above licensed power level, which represents a 15 percent power rise above our current power level.

The implementation of uprate at Brunswick will be very similar to those you've seen before, with a two-step uprate. The first being about 112 to 115 percent, and then the second being up t 120 percent.

These are some parameters that you can look at to see the change in power. Currently, we're 2558 and going to 2923. You can see the steam flow, and feed flow, of course, would increase proportionately to that. Also, the reactor pressure change we had previously done for the five percent uprate, increasing it up to 1045, there is no pressure increase associated with this uprate, which you've seen simplifies the analysis somewhat.

We have several modifications very similar to previous uprates in terms of the type of modifications that we're doing. We only have two that are safety related modifications. The first which was of interest is our Standby Liquid Control, our SLC System. We are increasing the boron concentration to support cold shutdown. We are making a modification to implement that. That's going to be done actually with the second fuel load of GE14. We have to change our fuel type to support the two-year fuel cycle from GE13 to GE14. Along with the higher energy, the significant power increase, we're going to be changing our boron concentration in SLC.

MR. SIEBER: Is it necessary that you make that modification, that change, to accommodate this core? Or are you doing it just to gain greater control and ease of operation?

MR. KITCHEN: The change is necessary. The degree of the change is somewhat -- there is some flexibility there. We need to achieve a 720 ppm boron concentration in-vessel. Currently, the requirement is 660. And we could do that in several ways. We are going to do that in such a way to support, as we'll show later, right now we require a two-pump SLC operation to achieve shutdown. The way we're doing this modification will enable us to reach success criteria with one pump. So we have to do a modification, but the type of modification or the degree that we're doing it there's some flexibility.

MR. SIEBER: On the other hand, you could just increase the concentration and continue to use two pumps, and you would still be safe, right?

MR. KITCHEN: Yes, sir.

MR. LEITCH: This modification occurs -- is necessary to support what we'll call Phase 2, that is, the ultimate uprate power, or is it necessary to support Phase 1?

MR. KITCHEN: Actually, it's required for the second load of GE14 fuel. And the reason I distinguish with that is that we actually loaded GE14 on Unit 2 at our previous refueling. So our first uprate outage on Unit 2 will be our second load of GE14. So really the requirement is tied to the fuel loading as opposed to the uprate stages that we're planning to do directly. We have a commitment, which I'm sure the Committee has seen, we've made a commitment to the Commission to make that change and also to make the change in such a manner that one pump will support success criteria for SLC.

MR. LEITCH: You have committed to do that?

MR. KITCHEN: Yes, sir. Since the ACRS Subcommittee, we have provided a commitment to the

Commission.

MR. LEITCH: Thank you.

MR. KITCHEN: The other safety related modification relates to our electrical buses. Our emergency buses are powered from off-site through our balance-of-plant.

MR. LEITCH: Just before we leave this, I'd like it if we could --

MR. KITCHEN: Yes, sir.

MR. LEITCH: Is there another modification associated with the relief valves on the SLC pumps? Is that part of what you're speaking -- in other words, does what you say just refer to the boron concentration or is the same timing and all involved with the relief valve modification?

MR. KITCHEN: The relief valve modification is not tied to -- not really an uprate requirement. It is tied to an issue with under ATWS conditions where depending on how quickly you inject you can result in relief valve lifting. Mark, I can't remember if that's --

MR. GRANTHAM: This is Mark Grantham, Carolina Power & Light. We are planning to replace the relief valves with a higher lift pressure that will gain us 50 psig in relief valve margin. That is currently planned for the next Unit 2 outage and the following Unit 1 outage. There is no formal commitment for that, but right now that is planned activity.

MR. LEITCH: Very good. I understand. Thank you.

MR. KITCHEN: The second safety related modification that we show here is tied to our electrical load supply. As I mentioned, the emergency buses are powered from off-site through our balance-of-plant buses, and with the higher loads that we are putting on our balance-of-plant buses to support uprate, larger pumps and motors, et cetera, that are required, there's a bit more of a challenge on our voltage support for degraded grid voltage reset; in other words, to be able to maintain the off-site power support to the emergency bus, which is obviously desirable.

To support that, we're putting in what we call a Unit Trip Load Shed. This is a tiered support. We can select certain standby balance and plant loads, for example, a standby condensate pump, standby condensate booster pump, to trip or not to start -- excuse me, their standby to not autostart in the event we have a unit trip. So that prevents large loads on balance-of-plant from starting and further lowering the voltage. This modification involves a select switch which is key-locked on the individual loads that are selected to not start in the event of a unit trip. And it will ensure that we maintain required voltage to the E buses under unit trip conditions from off-site power.

MR. LEITCH: That autostart defeat does not interfere with the normal autostart on, say, loss of low suction pressure or something like that. In other words, if you lost a condensate pump but didn't trip the unit, you'd still be able to start the other condensate.

MR. KITCHEN: That's correct. It does not affect autostart under normal conditions.

MR. LEITCH: It's only after the unit has tripped --

MR. KITCHEN: Yes, sir.

MR. LEITCH: -- that this comes into play.

MR. KITCHEN: That's correct.

MR. LEITCH: Thanks.

MR. ROSEN: In reading the staff's safety evaluation on this uprate, it was not clear to me whether or not this Unit Trip Load Shed would be required if you were not making an uprate. Can you help me with that?

MR. KITCHEN: That's correct. The uprate raises horsepower requirements on the load supply by balance-of-plant buses. And that's the reason for the modification.

MR. ROSEN: The only reason. There were no grid reasons to not -- if Brunswick was not making this uprate that you wouldn't go ahead with these changes anyway, changes to the switchyard and other changes to help with grid stability in the region?

MR. KITCHEN: Not for the Unit Trip Load Shed. Now the grid stability, yes, and that's the second -- that's a balance-of-plant modification.

MR. ROSEN: Well, maybe you could help me when you get to that to --

MR. KITCHEN: Sure.

MR. ROSEN: -- clarify that.

MR. KITCHEN: This would not be tied to the grid situation; this is tied to uprate.

MR. ROSEN: Okay.

MR. KITCHEN: balance-of-plant, as I mentioned, we're going to be doing the uprate in two phases. There are a number of balance-of-plant modifications. I think the Committee will see these are very similar in type to the others that we've looked at -- turbine replacements. One that we've asked about was the power system stabilizer and out-of-step protection, and that is related to grid. It is related to uprate, it is also tied to grid loads in the area.

And there are a couple of -- I'm sure there are many -- factors that lead to instability situations. One is tied to the unit load itself. The larger the R load, the more susceptible we are to grid instability. Also the larger load in our area, the more susceptible the grid instability. So even with that uprate, we could have conditions which might make us want to make these modifications to ensure stability. But the driver for these is really the uprate itself.

The power system stabilizer is basically a feedback loop on our excitation to stabilize any oscillations on the generator. The out-of-step protection is just that. If we end up with an out-of-phase situation or leading to an out-of-phase, we'll trip the generator rather than end up tripping off-site breakers to ensure not only generator protection, which in this case is really secondary, but really to ensure that we don't have a cascading grid failure.

MR. POWERS: Why wouldn't it be prudent to go ahead and make these changes to the grid stability, allow that to sort itself out for a while and then go the power uprate?

MR. KITCHEN: Well, in effect, we are doing that. We've already made these changes on Unit 1. The power system stabilizer and out-of-step is already installed on Unit 1, and testing was conducted in association with the startup. Of course, we have not uprated. We plan to do that shortly after this meeting. But we have done testing at current power levels with these modifications.

MR. POWERS: Then why not allow things to operate for a cycle, two cycles?

MR. KITCHEN: It's already -- I mean these types of modifications are not unique to the uprate. They're fairly common in the industry. The testing that we perform demonstrates the -- clearly demonstrates the performance of the system. And if we had a problem with the system, we could maintain current power levels or simply remove them from service if required. So there really wouldn't be any benefit in delaying the uprate implementation one cycle and test it.

The Phase 2 modifications at the plant are really not quite as extensive, although they are major modifications to the main transformers, other additional feedwater heaters and moisture separator reheaters. And both of those are tied to uprate because of not only performance but also to support efficiency.

As you well know, the uprate leads to degraded margins. We'll talk about those quite a bit in our presentation today. But I wanted to point out also there are some things that we're doing that will either regain or maintain margins in the operational area. Just to give you for examples, we've talked about the standby liquid control modification, and we're doing a little more than you would say you have to to maintain our margin on SLC. We're going to go from the current two-pump to a one-pump requirement for operability there. That's definitely an enhancement.

We also are changing our Power Range Instrumentation System, and that does a couple of things for us. Currently, we operate on thermal-hydraulic instability solution E1A, which is a prevent solution. With the new powering system, we're going to option three, which provides detect and suppress, a SCRAM, based on instability and detection, which we see as an enhancement, particularly for the operator interface. It's a little better digital controls interface, as well as reducing maintenance requirements, less surveillance is required, the system eliminates half SCRAM. So there are some benefits there with this modification.

Also, I think you may have seen some uprates where condensate, condensate booster pumps all were required to operate to support uprate. We elected to improve the system to maintain our standby pump capability. We didn't want to give that up with the uprate.

And, finally, we've talked about the power system stabilizer, but that will, as was pointed out, not only because of uprate but also because of grid growth would be a mod that would be desirable to maintain margins.

The Subcommittee asked about the interim operation, because with the two-step implementation we would get the license for reactor power operation up to 120 percent and then be plant-limited by balance-of-plant equipment. And the question was how do you control this in the interim? There are a couple of aspects of that.

One, during the startup and the power ascension for implementation of the uprate, we are going to do testing, as you've seen before, response testing on our controls for the turbine and response of the digital feed controls, as well as performance monitoring on balance-of-plant equipment. And we'll be looking at where we have predictions based on our analyses on the system, where we expect parameters to go. But we'll be looking closely at the actual plant performance to assess that we're not limited in some criteria before we expect it.

We'll translate that procedurally to an operational guidance as far as plant control, because you want the operators to be able to operate the plant on something they're looking at in the control room as opposed to a BOP limit in the plant, although that's what will really limit it. And the way I look at this, it's really not different today than if I were to have a component out-of-service in the plant, like a condenser water box, for example, which would limit us in reactor power. It's really the same type of operational control that we would have.

So these are the plans we have for our transition, just to basically test, monitor and then establish guidelines.

MR. LEITCH: You referred to turbine testing. Could you say a word more about exactly what kind of turbine testing you plan to do?

MR. KITCHEN: Well, during the startup, of course, we did the routine vibration and over-speed checks, but the testing I'm specifically talking about are controls tests. We do pressure regulator fail-over. We have backup and primary controls that pressure regulators will fail the primary over. We'll do step changes in pressure to verify the valve response is correct. And we'll also monitor the system response, it's called incremental regulation, to make sure that the valve position response is as you would expect based on the power increase.

MR. LEITCH: Now, will the EH -- I'm just a little confused -- is the EHC system going to be modified prior to Phase 1 or prior to Phase 2?

MR. KITCHEN: It's part of the mod requirements for Phase 1 and --

MR. LEITCH: Phase 1.

MR. KITCHEN: -- it's part of the -- really, it's tied in with the high pressure turbine modification. Specifically, we operate in partial ARC, 3-ARC control today, and we'll be going to 2-ARC control, partial ARC with uprate.

MR. POWERS: Do I understand correctly you're going to train the operators from what they do now to what you do at an interim, and you're going to untrain them on that and train them for what you'll do at the final power up?

MR. KITCHEN: We started training operators actually last year on the modifications that are being installed. In fact, the modifications that are installed in the Unit have been installed in the simulator, and the operators have trained on the equipment itself. We're training this phase, which started this week, on the actual uprate -- the license change, the technical specification changes and the allowed operation. So, really, operationally, the only change is the modifications and then the licensed power. They will train on transients associated with it.

MR. POWERS: So right now we have a situation where the operators have a plant that they run with one set of limits and are training on a different set of limits?

MR. KITCHEN: They are -- well, we always train on the current plant operation. The operators are training on what the limits will be in terms of power operation with uprate approval. Now, the parameters that control like our average power range monitor trips, main steam line flow set points, those will only change one time. They will change with the uprate, and they will be that way for both stages. So really it's a lower power level training up to full power operation.

MR. ROSEN: Before you get too far away from it, let me ask, have you something in your presentation this morning, some more insight that you can offer us on the power range instrumentation changes? Of is what you said about it all that you plan to say?

MR. KITCHEN: That's all I planned to say. We could talk through that more if you like. The system that we're installing is the General Electric NUMAC System. It's a digital system that installs not only with the change in the instrumentation itself, but it also provides a change in our instability solution protection. We call it Operate E1A which has areas that the operators avoid and areas where there would be an automatic SCRAM, just based on where you are located in the power operation region.

With Option 3, the stability solution is tied to what's called period-based algorithm which looks for certain frequencies which are representative of thermal-hydraulic instability and has a threshold based on the number of cycles counted and the amplitude of those cycles. If it meets those criteria, there's an automatic SCRAM. So regardless of where you are operating, if the system sees an instability, there would be an automatic SCRAM.

MR. SHACK: I thought there was a problem with actually implementing Option 3 at the moment because of a Part 21 --

MR. KITCHEN: There is an industry issue with the Option 3 stability solution. There is a Part 21. Under certain circumstances, the generic curve that is used to determine the set points for the operating cycle can be non-conservative. And along with that Part 21, the GE resolution or the GE interim guidance provided where there are certain calculations the fuel folks can do to determine if, for our specific operating cycle, if that curve bounds our set points; in other words, if they are conservative.

For Unit 1, which we've installed Option 3 on, those calculations have been performed and prove that the curve bounds Brunswick Unit 1, that the systems installed are operable on Unit 1 today and will be operable through the cycle. So Part 21 still applies, but for our specific application it's not impacted.

MR. POWERS: How many cycles do you have

to go through before the system actuates?

MR. KITCHEN: Don't know the answer to that. Jason, the question is how many cycles of instability before a trip?

MR. POST: Yes. This is Jason Post of GE. It has to establish a base period within a criteria which takes a half a cycle and then every half cycle after that it adds one count. So you have to -- it will take you about five and a half or six cycles to reach a count of ten or 11 counts. And then it also has to reach an amplitude set point. So, typically, 1.1 peak over average, and then the SCRAM will occur. So it could be, with a two-second period, we're talking around -- I think around ten seconds or so.

MR. ROSEN: How do you test that in the plant?

MR. KITCHEN: Actually, the system has some self-test features in the digital system. We actually tested similar to what we would do other systems. We can remove a channel from service and perform the set point verifications for the trips, also check the sensitivity of the system for a response to instability and the thresholds. Basically, it's not unlike any other system that we would test. It does have an advantage in that currently if we remove a channel for testing, we have to put in a half SCRAM. And with the new system, the logic is set up such that we can take one channel, one APRM channel out of service and not have a half SCRAM. So it's a pretty significant advantage. It reduces significantly the number of half SCRAMS that we have for routine testing.

MR. ROSEN: Well, you've described checking the set points and those sort of things, but do you actually check the oscillatory counting procedure algorithm in the software?

MR. KITCHEN: There's one. Jason, go ahead, address that.

MR. POST: Yes. This is Jason Post with GE. There's various parameters in there that cause the -- even with normal noise and the REM variation in the neutron flux signal, you will get periodic counts from your system. So there are some tuning parameters, and we make sure that the system is tuned adequately to give an adequate level of response for normal noise. It's a procedure we use to confirm system operation for an actual instability that occurred at Liebstadt. So we ensure that the system is adequately responsive during normal operations so we've ensured that when an actual instability does occur, we will get the counts.

MR. POWERS: I think what you said is that there is no test for this system, this Plant.

MR. POST: It's continuously being tested. You notice the -- as I said, during normal operation, there is some level of counts. In fact, one of the original surprises when we put the system in was we got more counts than expected. It was being very responsive during normal noise, and you could get single channels that would give you five, six, seven counts just from normal noise and the random nature of that. So it is -- you know continuously that it is operating.

MR. POWERS: Do you understand that, Steve?

MR. ROSEN: Only marginally, Dr. Powers.

MR. POWERS: It seems to me that when you find you've got a noisy channel and you suppress the noise, you also suppress its ability to respond under actual event.

MR. ROSEN: Well, that comes down to the operating procedure. If they are suppressing noise that way, you're right. If you get five or six or seven counts during normal operations just because of random variations of the signal and you need ten or 11 to trip the plant, I would suspect the operators are starting to get a little nervous.

MR. KITCHEN: But the tuning procedure that Jason is talking about is really set to verify that we have appropriate response so that the operator has enough time to take action if there's an instability. But the system will still provide protection, and also not so low that we have -- you don't want a lot of nuisance alarms associated with the system. So that's the band that you tune it within, but there's not a situation where you tune it to a point where you eliminate protection from the instability of that.

MR. LEITCH: It actually takes two parameters for the system to actuate. You know, it can be counting forever, but if the signal's not -- the variations are not big enough, it won't make a protective action.

MR. KITCHEN: That's correct.

MR. LEITCH: So when you look at noise all you're doing is seeing whether it counts or not.

MR. POST: Just to reinforce that point, that's exactly one of the concerns with the Part 21 issue is that if we lower the amplitude set point too far, you'll come too close to where a normal noise event could cause an unnecessary SCRAM.

MR. KITCHEN: The power uprate for Brunswick is -- we do have a few exceptions to the ELTR. Generally, the guidance in the ELTR was complied with totally. There a few exceptions. Three of these are related to the constant pressure nature of this uprate and some of the simplifications which are warranted. We feel that these can be discussed later in proprietary section. These as well as the fourth one I've identified up there, which is large transient exception, are similar to what have been presented before with other uprates. Basically, the large transient testing is associated with the MSIV closure and generator load reject, and we would like to waive both of those tests.

MR. ROSEN: Some of the other plants that have come before us have included a re-circ runback feature. I don't see that in your proposal.

MR. KITCHEN: The ones that I'm familiar with, sir, are associated with the condensate system itself in that they need to run all the condensate pumps to support operation. In that situation, if you have a pump trip, you need to reduce power to basically the original power level, and they do that with a re-circ runback. In our case, with a standby pump, the standby pump would start, and there's no need for runback.

MR. ROSEN: Right. And I was waiting for you to make a further comment on large transient testing.

MR. KITCHEN: Certainly can.

MR. ROSEN: There have been a number of questions raised about the need for that testing by members of the staff and also by this Committee. And there are currently considerations in the staff of setting up some criteria for when large transient testing might be required. Are you aware of those discussions?

MR. KITCHEN: I'm aware there's been quite a bit of discussion about the large transient testing. I'm not familiar with the specific Committee discussions.

MR. ROSEN: Well, the staff established a panel to look into the need for integrated testing for extended power uprates. And that Panel has concluded its report, which sets up --

MR. MARSH: Mr. Rosen, we may into an area which is not publicly released yet, okay? This is the area of the Panel and how the Panel looked at it. So can I ask you to forebear till we get into a --

MR. ROSEN: Oh, I see. Is the staff going to address some of this?

MR. MARSH: To some extent.

MR. ROSEN: And the implications of that to the Brunswick --

MR. MARSH: We're going to discuss with you what our plans are regarding that Panel and what its recommendations are and how we're going to proceed.

MR. ROSEN: Well, it seems to me that there's a question here as to whether or not the outcome of all of that will be applied to Brunswick.

MR. MARSH: Let's see, what can I say? We are going to consider the extent to which the decision in the guidance that will be made should be back-fit to this Plant or to any plant that's already gone through this process.

MR. KRESS: Will that require back-fit --

MR. MARSH: It involve looking backwards into the back-fit type of procedure, that's right.

MR. ROSEN: So that would be clearly true for plants whose license uprate has been approved.

MR. MARSH: Yes, sir.

MR. ROSEN: For Brunswick, which is not quite there yet, would it apply to them?

MR. MARSH: Yes, it would.

MR. ROSEN: In other words, as a back-fit to them or --

MR. MARSH: Yes, it would.

MR. ROSEN: -- or in their case, as part of their approval, should they be -- should this request be approved? Do you see the difference I'm saying?

MR. MARSH: We recommend we continue on the same track that we've been on, because the guidance isn't yet developed nor has the back-fit analysis been done. So we recommend continuing along the track that we've been on, which is to approve -- grant a request to waive those tests. Staff will develop guidance, will apply back-fit analysis to that guidance to find out whether this Plant and others should do the large transient testing. Have I answered your question?

MR. ROSEN: Not exactly, because it would seem to me that plants to which you have to apply the back-fit rule, 5109, I assume --

MR. MARSH: Right.

MR. ROSEN: -- would have a higher threshold in terms of whatever the criteria turn out to be than a plant which was licensed for uprate with the understanding that when the tests criteria were determined that they would be applied to Brunswick. And depending on whether they fell within the criteria or not, they would either be applied to them or not.

MR. MARSH: Right. Well, we haven't yet decided whether large transient testing should be done, okay? That is still part of the charge that we're being given by the Office Director. And once the decision is made, then a guidance is developed as to whether it should or should not be done. Then we'll apply the back-fit to it. So we would be premature to condition this license or in any way use that criteria beyond what the staff's acceptance criteria is now.

MR. KRESS: In order to apply the back-fit regulatory analysis, you have to determine the risk REMS that you offset by this.

MR. MARSH: Sure.

MR. KRESS: How in the world can you ever do that for something like large transient testing?

MR. MARSH: That's just one of the tests that's embodied in the 109. There are other tests that are there.

MR. KRESS: I know, but if it fails -- I mean you have to pass that test too.

MR. MARSH: Sure. Sure.

MR. KRESS: And I just don't see how you can actually do that.

MR. MARSH: We'll have to develop -- we'll have to study it in detail, which is what the charge is all about, and develop regulatory guidance and decide whether or not it should be done, and then that's a forward-looking issue. And then in terms of backward-looking, we'll have to apply the 109 test to find out whether it should be done, whether the gain is worth the cost in terms of REM, in terms of safety margins and if it comes to be an adequate protection issue, if that's where it is. But that is the charge.

MR. ROSEN: It seems like we're working on a very short fuse here, from my reading of the information, which I now understand is not released yet. But that all of this is very near-term stuff.

MR. MARSH: Our charge from -- I was going to do this at the beginning, but I'll be glad to do it now. The Office Director has asked us to develop a plan to give back to him by the end of this month with how we will formulate the staff guidance and the extent to which we'll apply the back-fit. We'll be glad to, of course, brief the Committee on that and how we do that. We haven't yet set the time frame when we will do that, but it's thought to be this year. This is a this year type of an effort. So it's a short-term effort.

MR. KRESS: Have you already decided this is not a compliance issue and therefore is a back-fit?

MR. MARSH: It's premature to say that. I think we have to hold out on that. We have to think about that. My impression is that it would not be since we are, at this point, saying this licensee is in conformance with the regulations, go forth without testing. So unless some other regulatory requirement emerges when you look at the back-fit analysis, if you judge that they're not in compliance with the regulation, then you'd be in the compliance exception, but we'd have to study that in more detail. I don't believe so.

MR. KITCHEN: Can we move on?

MR. SIEBER: Yes.

MR. KITCHEN: There are a few unique aspects of Brunswick uprate I just wanted to point out to the ACRS. First, we do have, as we talked about, some actions that we're implementing to enhance grid stability. Secondly, we are, I think, the first plant you've reviewed that's hydrogen water chemistry versus normal metal chem.

Finally, we have significant energy requirements to support our operating cycle. We are asking for 120 percent power operation relative to our original license, and we are a two-year fuel cycle. We also operate at 97 percent capacity factor. That's our design criteria, and we've done quite well at Brunswick. So those things combined give a pretty significant energy load for the cycle. And those impact, of course, our fuel design.

With that, we talked about fuel. So, Tom?

MR. DRESSER: Good morning. My name is Tom Dresser. I work for CP&L's BWR Fuel Engineering Group, and I'm going to discuss very quickly five different topics related to the reactor core. The first two, the fuel bundle and the core design and the ATWS, are performed completely consistent with the previous mils and with the generic methodology of ELTR 1 and 2. The last three, the transient analysis, thermal-hydraulic stability and LOCA analysis, each take some kind of exception to the generic methodology, which I'll discuss when we get there. And those last three topics do contain material in my presentation, which is proprietary to GE, so we'll pause from the second and third topic and go to closed session.

The fuel bundle and core design that is performed in support of the power uprate itself to provide the input to all the fuel-related tasks is done for a full equilibrium cycle. And the design targets to be achieved by that equilibrium cycle are similar to what's been seen by the ACRS for other plants. As Bob mentioned, Brunswick is a higher energy cycle because of the 24-month refueling outage and the excellent operations.

That forces us to do a number of physical changes to achieve the energy requirements. The first is that we need to change our fuel design from GE13 to the ten by ten GE14 fuel design. Now, amongst many other attributes, the GE14 is a heavier bundle with about five percent more uranium in each bundle loaded. Additionally, we have to increase the enrichment on the order of four-tenths weight percent in that new fuel, and we have to increase the number of new fuel bundles substantially. The reload pressure goes from about 39 percent to about 47 percent to achieve this extra 15 percent power.

Now, by making all three of those changes, we do get the required energy for the two-year refueling cycle, but it does make for a more reactive core. So by the time we get to the full equilibrium cycle, we do need to make the Standby Liquid Control System boron equivalent change.

MR. ROSEN: What did you say about enrichment, would you repeat that?

MR. DRESSER: Yes. The enrichment must be increased. Of course, it's -- I can't give you one single number to cover everything, but the range of the enrichment increase is on the order of 0.4 weight percent.

MR. ROSEN: The increase is 0.4.

MR. DRESSER: The increase is 0.4. It goes from the highest sub-batch. The fuel goes from about 4.0 to about 4.4 weight percent.

MR. ROSEN: Okay. Now I understand. Thank you.

MR. DRESSER: And as Bob mentioned, we will need to make a change to the effective boron concentration of about ten percent, to go from about 660 ppm to about 720 ppm by equilibrium.

The last change that we need to make is pretty trivial. The tech specs power at which we start monitoring thermal limits decreases from 25 percent to 23 percent, but that is just to maintain the same absolute bundle power calculational basis as used generically for GE BWRs in the fleet.

MR. SIEBER: It seems to me that the per rod duty is going up substantially in this fuel. And if you look at GE13, that's like spaghetti, and GE14 is like vermicelli.

(Laughter.)

MR. SIEBER: From the standpoint of bending and --

MR. DRESSER: That's true. The bending moment in that kind of thing is going to be smaller for the GE14. The linear heat generations is a lot less for the GE14, and the limit goes down and the actual amount of linear heat generations goes down even more. One thing that going with these very large reload fractions it's not possible to design the fuel cores with the same fuel efficiency that we've been used to in the past. And so the average exposure on the fuel goes down a lot. So whereas our batch average exposure limits are 50,000 megawatt days per ton and we had been able to design our lead sub-batches and bundles to go up to the 48 or even sometimes over 49 megawatt days per ton, with this new core design, our lead bundle burnups are in the range of 45, 45.5. So it's a whole lot less exposure on the fuel, and that should improve the --

MR. SIEBER: On the other hand, you're

going to have maybe six percent of the bundles that will be in core for three cycles?

MR. DRESSER: That's correct. And that --

MR. SIEBER: What is the peak bundle burnup?

MR. DRESSER: Those are the bundles that contribute to that 45.5. There are also bundles which are substantially less exposure. So the high bundles are in the range of 45.5. And that's because a lot of these bundles spend time near the outside of the core where the flux is less.

MR. SIEBER: Thank you.

MR. POWERS: Tom, you just recently experienced the fuel leak, I believe. Was that in GE14 fuel?

MR. DRESSER: Yes. We did have two GE14 fuels that have leaked. We've removed those from -- this is the Unit 2 Plant. Those have been -- the Plant was shut down and those bundles were removed. They'll be tested. We'll go examine those bundles in about two months to --

MR. POWERS: Okay. So you don't yet know the nature of that --

MR. DRESSER: That's correct.

VICE CHAIRMAN BONACA: Did you shadow

those failed pins?

MR. DRESSER: Yes, we did. They failed nearly a year ago, and we did power suppression testing and then suppressed those bundles. It was fairly effective in controlling the degradation of the fuel. And the bundles were located in a vicinity that had been identified.

VICE CHAIRMAN BONACA: So you must have lost quite a bit of cycle length.

MR. DRESSER: Well, because this -- we shut down the Plant in the middle of a cycle, and so we will lose, I think, on the order of a week, not too much.

VICE CHAIRMAN BONACA: You shut it down? All right.

MR. DRESSER: We did shut it down and we threw those out and we've started the Unit.

The first actual power uprate cycle is in Unit 1, Cycle 14. I'm going to go through this relatively quickly. The design goals are similar. They were all met. It required a slightly smaller relay fraction to achieve the energy, about 46 instead of 47 percent of the core. Otherwise it's not that different from the equilibrium cycle.

One big difference is that there is, as

Bob mentioned, no need to modify the Standby Liquid Control System boron concentration for the cycle because of the single reloaded GE14 fuel. One thing that's interesting about both this and equilibrium design with those large batch fractions is that the power -- the radio power distribution is very, very flat for Brunswick, and that will affect many things that we look at today. One of the things it affects right here in this cycle is the safety limit MCPR must be increased from 1.10 to 1.12.

MR. ROSEN: Do you have some way of characterizing this very flat versus what it was before?

MR. DRESSER: Yes. I have a couple -- I have a visual which I'm going to share with you.

(Pause.)

I'm going to respond to this in two ways. I'm going to show you a visual first and then give you some numbers. This is an open session. I think is probably not proprietary. This is last cycle. This is a radio power distribution for the bundle peak powers. The blue is the highest power density, 1.2 to 1.4, and peach is 1.0 to 1.2. And then as we go progressively further out along the radius of the core, the power densities get less and less. That's basically what the non-power uprate cycle looks like.

Now, if we go to the current cycle, the first power uprate, we see some migration of power towards the outside and a little bit lower power density towards the interior of the core. And then if we look at the full equilibrium cycle, it's more pronounced.

Now, to put some numbers on that, the highest sub-batch power fraction for Cycle 14 is about 1.22. By equilibrium, it goes down to about 1.19. And in comparison, I think that the last plant that came before the ACRS and showed a flat power distribution that corresponding number was about 1.26. So this is the flattest power distribution that has been seen.

MR. ROSEN: You know, visually, if you put -- somehow maybe you could show the first and the last one on the same -- the blue is the high power regions, am I correct?

MR. DRESSER: That's correct. That's the highest power.

MR. ROSEN: Okay. So if you just look at -- do some sort of mental integration of that --

MR. DRESSER: To me, the numbers might be a little bit easier to understand, the 1.26, 1.22, 1.19. I can look at this and see visually that the equilibrium is lighter, it's not as dark as the current cycles.

MR. ROSEN: I believe you.

MR. WALLIS: Did you average in the --

MR. SIEBER: That's a first.

(Laughter.)

MR. WALLIS: You're pushing the power up towards the edge, you can see that. The edge is the narrower.

MR. DRESSER: That's correct.

MR. WALLIS: That's the clearest thing you see from that visual integration.

MR. ROSEN: The edges, is that what you were looking at?

MR. WALLIS: Yes. Power towards the side is raised.

MR. DRESSER: Would you like to see those again?

MR. ROSEN: Yes. Would you go back to that?

MR. WALLIS: I'm just trying to help you with your integration.

MR. ROSEN: I was looking at the blue.

MR. WALLIS: Yes, but the blue is

misleading. Look at the edges. You find those skinny, it's a yellow region. So that the low power regions are lower.

MR. ROSEN: Yes. Now I see that.

MR. WALLIS: Of lower extent.

MR. ROSEN: Okay. Thank you.

MR. DRESSER: To conclude for the fuel design itself, it's necessary to make some physical changes to the plant and load much more fuel and make a change to the Standby Liquid Control System. But in order to maintain the types of design margins that we typically expect, it does not require any change to our methodology or expectations.

The second topic would be ATWS. This analysis was done consistent with the ELTR as well so that the four limiting ATWS events were analyzed. The one that's of greatest interest is going to be the pressure regulatory failure open event, which shows a peak vessel bottom pressure increasing to about 13 pounds less than the ASME service level C limit. Licensing-wise, I guess that's 12 pounds and change more than it has to be in terms of margin. But it appears pretty close. What offers comfort in that amount of margin here is that this analysis is done not with normal transient, best estimate kind of inputs, but the estimates are conservative. The set points and things are biased to be towards the worst allowable value limits. Also, the SRV capacities, which would be very important to this, are only 90 percent of the actual capacities. And this analysis does assume one SRV is out of service as well.

Then the final thing is that these calculated results are using GE's ODYN code. If we had recalculated these using GE's more sophisticated and accurate TRAC-G code, that, by itself, would produce well over 100 pounds additional margin. So though the numbers appear fairly close to the design limit, there really is no concern with respect to actual safety here.

MR. WALLIS: So you know what track it would predict without actually running it?

MR. DRESSER: Well, G's got a lot of experience with TRAC, so that's just a rule of thumb kind of number. It produces much lower results.

In the interest of time, I'll just comment that the other three analyses show a great deal of margin to be respective limits, and unless we have particular questions about that, I'll --

MR. ROSEN: Well, only that the peak clad temperature goes down. Would you want to comment on that?

MR. DRESSER: Yes. The peak clad temperature goes down. There are a couple other facts, but probably the most important thing for the ATWS is that with power uprate we have a higher void fraction and a much more bottom-peaked flux distribution so the peak node is lower in the core where there is more water and less void in the power uprate case, and you get a better heat transfer out.

These results, in general, for the ATWS show that the ATWS analysis for Brunswick is done consistent with the standard generic methodology, and there is no requirement to support the ATWS now. It's just to make changes to the Standby Liquid Control System boron concentration. There's no need to make changes to the actions that the operators take, and the standard designs are satisfied.

Next, we're going to want to go to the final three topics, and we'll need to go to closed session.

MR. BOEHNERT: All right. If we can have anyone from the public please leave the room. It will be, I don't know, a short time. There's not too many slides. I will come out if there's anyone here. Nobody here.

Okay. Well, let's proceed to closed session then. And, Transcriber, if you'll go to a closed session transcript, please. Thank you.

(Whereupon, the proceedings went into Closed Session.)

MR. WILTON: Good morning. My name is Blane Wilton, and I'm the Supervisor of Reactor Systems at Brunswick Nuclear Station. I'd like to discuss the reactor vessel and internals, specifically, the effects and impacts of power uprate as it relates to the internals.

What we found is the reactor vessel and all the internals were addressed in accordance with ELTR. The impacts that we found were our PT curves, our pressure temperature curves, were impacted. Our current curves that we're operating on are good through March of 2003, have been approved with the effects of power uprate included. We have a commitment to resubmit PT curves to the staff for review by June of 2002 with the new fluency methodology, in accordance with Reg. Guide 1.190 incorporated.

Fluency was also affected by power uprate. What we saw is that fluency did not increase proportionally with the power increase. There was a greater than a 20 percent increase. The reason for that is just the core configuration going to an equilibrium core, pushing the power farther out to the periphery of the core, increased the fluency that we saw.

Embrittlement. Embrittlement was affected. We're an older Plant, so we don't have full SHARPIE test data on our vessel materials. Ten CFR 50 Appendix G requires that you meet certain criteria for both initial plate materials as well as end-of-life materials. If you don't have full materials, you can do what's called an equivalent margins analysis. We redid that for our Plant, found that we met all requirements. We also did a plant-specific one on our N16 nozzles because those are in close proximity to the beltline region, and they met all limits also. So, therefore, embrittlement was okay.

Fatigue. Fatigue is also affected. We did a fatigue evaluation on our limiting components, and what we found is that all fatigue values are met through end-of-life plus 20 years. We looked at the 20 years just to make sure, because we are looking down the road at life extension. But we met it for end-of-life, plus we met it for end-of-life plus 20 years on all of our components.

MR. SHACK: Just in your --

MR. WILTON: Sure.

MR. SHACK: You're in a normal hydrogen water chemistry, so are you continuously monitoring ECP somewhere in the vessel?

MR. WILTON: We do not have ECP monitoring installed. We don't have ECP probes. What we do is we have run models of plant-specific models of our Plant; we've done that. We also monitor parameters like main steam line rad monitors, radiation --

MR. SHACK: So you monitor N16.

MR. WILTON: Yes.

MR. SHACK: Do you monitor oxygen coming off?

MR. WILTON: We don't monitor oxygen, but we monitor hydrogen concentration in our feedwater.

MR. SHACK: Have you run the radiolysis model with the higher fluency?

MR. WILTON: Yes, we have. And what we've found is that our protection -- host power uprate is actually better, at least as good or better with the high fluency, because the radiolysis model is affected by fluency. The higher the fluency, the more efficient the recombination reaction is. And, therefore, what you see is that your protection actually goes slightly more negative. And when we saw that, we questioned that, and we went back through EPRI and had them validate our model for us. And what we saw is that we actually had at least as good or better protection under power uprate conditions than we currently have.

MR. SHACK: Now, in your feedwater lines, because you have hydrogen water chemistry, do you have any more difficulty in maintaining a reasonable oxygen level in the feedwater?

MR. WILTON: We haven't seen that, no.

MR. SHACK: What do you maintain, 20 ppb?

MR. WILTON: Yes, 20 ppb oxygen in our feedwater lines. And we inject at 39 and a half SCFM, which equates to about 1.0 to 1.05 ppm in our -- so we are a moderate hydrogen water chemistry plant. And our plan is to continue maintaining hydrogen at our current levels. Now, how we validate that is we have an extensive inspection program. So we're following the guidelines of the VIP, we maintain our water chemistry in accordance with the VIP guidelines, and our model shows what our ECP levels are, our inspections, then validate that. What we've seen, we're not -- where we do have cracking we're not seeing crack growth, which is what our models show -- say that we should have. So our inspection program is really a validation of what our models and all show us. And we've committed -- you know, we will continue to do our inspection program through end-of-life.

MR. FORD: Just a curiosity question. Do

you inject oxygen into the condensate?

MR. WILTON: Yes, we do.

MR. WALLIS: May I ask a question for clarification?

MR. WILTON: Certainly.

MR. WALLIS: Are you a noble chem?

MR. WILTON: No, we are not a noble chem plant.

MR. WALLIS: Do you plan to be?

MR. WILTON: No. At this point we do not.

MR. ROSEN: You say you inject oxygen. Do you really do that or do you -- are you injecting air with oxygen in it?

MR. WILTON: It's air.

MR. ROSEN: It's air.

MR. WILTON: Yes, I'm sorry. Any questions?

MR. GRANTHAM: Good morning. I'm Mark Grantham. I'm the Design Superintendent on our Power Uprate Team. I'll be talking about our containment analysis that was performed and the impact of that analysis on MPSH for ECCS pumps.

The containment analysis was performed in accordance with the ELTR. For data comparison purposes, what we have is actually the first data column, and all these columns are 102 percent of reactor thermal power. The first column provides actually our current UFSAR values. We re-ran the analysis at 102 percent of our current licensed thermal power using the same assumptions that were used in our power uprate analysis. And what this does it provides a direct comparison for the uprate to provide basically the overall impact to the containment analysis strictly from the power increase.

Reviewing the data, drywell pressure under EPU conditions goes up to 46.4 psig. The acceptance limit is 62. Drywell space temperature 293 degrees F versus an acceptance limit of 340. Wetwell pressure, 31.1 psig versus an acceptance limit of 62. Suppression pool temperature, 207.7 degrees F versus an acceptance limit of 220. So we still maintain a substantial margin under uprate compared to the acceptance limits.

VICE CHAIRMAN BONACA: What's the difference in methods between the FSAR and the current?

MR. GRANTHAM: There's four main differences. The FSAR analysis was performed using the homogeneous equilibrium model for determining blowdown flows.

VICE CHAIRMAN BONACA: Okay.

MR. GRANTHAM: The power uprate model used Moody slip critical flow model.

VICE CHAIRMAN BONACA: Okay.

MR. GRANTHAM: The original FSAR analysis used nominal decay heat values, whereas the power uprate analysis applied a two sigma uncertainty adder to those values.

VICE CHAIRMAN BONACA: Okay. Thank you.

MR. SIEBER: This is, Mark, one containment?

MR. GRANTHAM: That's correct. The impact of that on net positive suction head -- currently, Brunswick is a Safety Guide 1 plant which currently does not allow credit for containment overpressure. As a result of the power uprate and in accordance with the allowances of the ELTR, we will, after the uprate, require credit for containment overpressure.

We actually looked at a short-term and long-term MPSH requirements. Short term is for the first ten minutes when operator action is not credited, and the pumps are assumed to be at run-out conditions. Under the first ten minutes, there is no credit for overpressure required. After ten minutes, the flows on RHR and course-rate pumps are assumed to be throttled back in accordance with the approved operating procedures. For the long-term analysis, the peak required overpressure is 3.1 psig. The actual available overpressure is 11.3 psig. In the license submittal, we've actually requested five psig to account for future changes and provide some margin between the limit.

The analysis that determined this was a conservative analysis in that for determining wetwell pressure, we assumed containment sprays were used, which actually resulted in a lower wetwell pressure. For suppression pool temperature, we assumed direct pool cooling was used, which actually results in a higher pool temperature. So for the MPSH evaluation, we actually have a combination of two different analyses, resulting in a worse-case condition -- lower pressure in the wetwell air space and higher pool temperature.

MR. WALLIS: Are we ready to move on? We are somewhat behind the original schedule, but it's because my colleagues are asking questions. I think it's appropriate that you continue to ask questions. But let's see if we can move along.

MR. PAPPONE: Well, I'll try to get through this as quickly as Ken. I'm --

MR. WALLIS: You're an old hand at this, Dan.

MR. PAPPONE: I'm Dan Pappone of General Electric. I'm the LOCA Process Lead, and I'll be going through a couple of things here. One is the feedwater and recirculation line break loading on the reactor internals, and then later on I'll go through the Appendix R.

What I've got here are the -- what I'm showing here are the external loads that come into the -- from the pipe break that come into the defective reactor internals that a set of loads that are due to the break itself. The jet impingement is from the pipe end of the break, the flow from the pipe end of the break hitting the vessel. The jet reaction is the break flow coming out of the vessel pushing. The annulus pressurization load, that break flow is -- some of that break flow is going into the space between the reactor vessel and the shield wall and pressurizing that region. And there's an asymmetrical loading trying to push the vessel over. And then there's also a pipe whip restraint on the pipe to keep the pipe from flailing around out in the drywell space. And those restraints are on the shield wall. The loads from the shield wall then get transmitted through the stabilizer to the vessel.

MR. SIEBER: That would be what we would consider the nozzle load? Or is the nozzle load something different there?

MR. PAPPONE: When you're saying the nozzle, you're talking about the reactor vessel nozzle?

MR. SIEBER: Right.

MR. PAPPONE: At this point, we've severed the pipe completely, so --

MR. SIEBER: So you're assuming there is no nozzle load.

MR. PAPPONE: There isn't a nozzle load at that point. We're not looking at --

MR. SIEBER: Something less than severing it completely would create a big nozzle load and maybe a complete severing of the pipe would not be the most restrictive case?

MR. PAPPONE: On the nozzle, right. Right. That's what I'd say --

MR. SIEBER: Sooner or later you would end up with a total break after the nozzle fails, right?

MR. PAPPONE: Right. Or, actually, most likely it would be a junction between the pipe and the safe end on the nozzle.

MR. SIEBER: Right. Right.

MR. PAPPONE: And then the other part that wasn't shown on there was internal loads that are going to affect the vessel. We've got blowdown pressure difference loads between the regions, which we have flashing through the different regions. And also flow-induced and acoustic loads. In the Subcommittee discussion, the flow-induced and the acoustic loads were really the topic of interest. And for those loads, we're looking at the recirculation line break as the limiting location. That break is down low in the subcooled region of the vessel. The other pipe breaks -- the other large pipe breaks are up in the saturated region. And the acoustic wave propagation isn't very good in saturated water compared to the subcooled water. Down in the recirc nozzle location, we've got a fairly restrictive area in that down-comer region, so that's where we get the flow-induced loads.

MR. WALLIS: Why should this change with EPU?

MR. PAPPONE: What changes with EPU is that because we've got a little more steam flow going out of the vessel, we've got a little more feedwater flow coming in, and even though the feedwater temperature is a little bit higher because we've got more flow coming in, when we mix that, we end up with a little bit lower down-comer temperature. And with lower temperature things like the flow loadings and the acoustic loadings get a little bit worse.

When we look at -- the components that we're looking at when we're looking at the flow-induced and acoustic loads are the jet pump and the core shroud and the shroud support. In the shroud support, we're only looking at the acoustic loads there. It doesn't see -- it's not in the flow field, so we don't see any flow loads on that.

And the approach that we take when we're evaluating these loads on the internals is we first try to fit within the original load definitions with the break flow driving source term. If we can do that, we stop there, because if the load definitions don't change, the structural stresses don't change. And if we can't fit within those envelopes with pencil sharpening, we go to the next stage. We look to see how much margin we have in the stresses to the allowables, and we eat into some of that margin. And the third step is to look at the actual stresses themselves from the original stress calculation and look for some conservatisms in that calculation.

So the original calculation may have used whatever the most conservative ASME structural approach is, and there may be another allowed approach that doesn't take out some conservatisms or may have done simple summing of both the first time you do the square root. Some of the squares may separate the loads into whatever their timing is. Like the acoustic load is in the first few milliseconds, and that's before the flow-induced loads come along. So we can separate those loads. They don't have to be combined.

MR. SIEBER: For all these steps that you went through to -- that I would call pencil sharpening steps, how far did you have to go with Brunswick under EPU conditions to come up with a reasonable answer?

MR. PAPPONE: That's the next slide. The components that do see an increase of load are the ones that are in that core flow and steam flow path. They're the ones that see an increase in the loads. And for most of the components, like shroud heads and dryers and the like, we have margined the allowables, so we were able to just accommodate those without having to do any pencil sharpening.

The acoustic loads we've refined our analysis technique down to a very fine mesh, basically water hammer calculation and reduced that driving forcing function. And on those components, the shroud head -- or the core shroud, the shroud support and the jet pumps are the ones that benefit from that. And we did do some pencil sharpening on the feedwater line break loads to get that down below. That wasn't fitting in the --

MR. SHACK: So for those you just refined the thermal-hydraulic analysis, and you didn't have --

MR. PAPPONE: That's right.

MR. SHACK: -- to mess with the stress analysis.

MR. PAPPONE: That's right.

MR. SIEBER: I presume that the more severe of these is the recirc line break, right?

MR. PAPPONE: Right.

MR. SIEBER: Okay.

MR. PAPPONE: Well, for the pressure difference loading, it's the steam line break that gives us highest load there because of the rapid depressurization and the very rapid --

MR. SIEBER: It's a bigger line.

MR. PAPPONE: Right. Well, it's about the same size pipe, but because it's up in the steam dome it pressurizes the vessel very quickly.

Okay. Next I'll be going through the Appendix R, and the case that was presented in the Subcommittee is really more of a what if beyond licensing basis case. So it's the only case where there's a heat up. In all of the Appendix R scenarios that in Brunswick's licensing basis, they have the RCIC system available. So there would be no core and covering heat up. But this is a postulated scenario that's a what if the RCIC didn't work or something like that, even though it's a protected system.

So conservatisms in this particular -- or the scenario for this analysis is we've got the loss of off-site power, ramp the feedwater down, no credit for the RCIC and standard with the Appendix R calculations we've got the nominal core power level and a nominal decay heat, realistic decay heat.

There are three relief valves that are used for the blowdown, and we're assuming that the operators initiate that blowdown at 40 minutes when they get a diesel started back up so that they have a low pressure coolant injection pump available for cooling once the vessels depressurize.

The conservatism in the analysis -- the biggest conservatism is that 90 percent of the actual relief valve capacity being used in the analysis, we're using the tech spec value as opposed to the actual valve capacity. With the Appendix R analysis, since this really is truly -- it is a nominal analysis, we could have taken credit for the full valve capacity. The ECCS performance values, the pump flow rates in the valve stroke times and what not, took those from the LOCA licensing analysis. And those again are minimums where we could have used nominal values and not taking credit for the RCIC.

And the results of this analysis, we've got a temperature of 1458 degrees. We've got an acceptance criteria for the Appendix R analysis of 1500 degrees, and that's based on no fuel damage.

MR. ROSEN: You said 1450, but your slide says 1468.

MR. PAPPONE: Fourteen sixty-eight. I misread it there. This was about 250, 300 degree increase over the current power case, and that's primarily due to the limited relief valve capacity, only using three relief valves. And, say, the standard Appendix K small break LOCA analysis were taking credit for five or six valves.

MR. SIEBER: Yes. But you assume three valves because you're operating from the standby panel --

MR. PAPPONE: That's correct.

MR. SIEBER: -- and it probably only has three valves on it.

MR. PAPPONE: It only has three valves on it, but the thing is with the three valves, we're more sensitive to a change in core power, because we're generating more steam.

MR. SIEBER: That's why you can't blowdown.

MR. PAPPONE: Right. And these results are consistent with what we've seen for the other power uprates in the Appendix R.

MR. SIEBER: It would have been better off to add another valve to the standby panel except for the fact that you would have to protect that division, right?

MR. PAPPONE: We'd have to --

MR. SIEBER: Which would be probably tough.

MR. PAPPONE: Right. We'd have to protect the cabling and add the logic to it. And the other part is that this really is a what-if calculation, because all of their Appendix R scenarios they've already protected the RCIC, so --

MR. SIEBER: Every calculation is what if until it happens, right?

MR. PAPPONE: That's true.

MR. SIEBER: Okay.

MR. PAPPONE: Back to Bob.

MR. KITCHEN: This is Bob Kitchen. I just want to close, discuss briefly the operator impacts and PSA results. The operator impacts -- of course, the testing that we have planned, as we've discussed, is per the ELTR with the exception of large transient testing. The operational changes that we see we've talked about the change in instability solution for the operators. The nature of the power uprate where we're operating on the power flow map is more restrictive than our core flow window, so that results in more power reductions to make rod pattern change. This is an impact the operators will see. So this is more of what we've been doing.

Then, finally, there is some small response in -- small reduction in operator response time. What we're talking about here is the just the higher power operation, you know, higher feed flow, higher steam flows. The transient simulations that we've run in the simulator is really almost imperceptible to the operator, and we don't see a significant impact there.

MR. ROSEN: What did you say about more power reductions? I lost track of that.

MR. KITCHEN: We were operating on a powered flow map in an area that's more restrictive. There's less core flow variation allowed just because of where we are. And that necessitates rod pattern changes more often to maintain full power. And to make the rod pattern change, we'll be doing more power reductions.

MR. ROSEN: Come down, make the rod power change and go back up, and you'll have to do that more frequently.

MR. KITCHEN: Yes, sir. So really, all in all, the operator impacts are relatively small.

The PSA results, just to show you, basically, the PSA review showed no change in success criteria or accident sequences. There were no significant changes in procedures so no significant impacts. And the hardware changes are like in-kind. Really, in terms of impact, there's a very small PSA. There were some slight decreases in operator response time in the PSA analysis associated with HPSI and RCIC level control in ATWS, but they were small: 30 minutes currently, 24 minutes under uprate; a six-minute reduction.

When we look at the PSA results, just the bottom line, across the top here is a current values for core damage frequency and large early release. With EPU, our psi review showed basically about 1.6 increase in CDF and about a four and a half percent increase in large early release. But as we --

VICE CHAIRMAN BONACA: Did you do an uncertainty analysis on these or are these point calculations?

MR. KITCHEN: I'll let Larry Lee address the analysis. Larry's with ERIN Engineering.

MR. LEE: Hi. This is Larry Lee from ERIN Engineering. Yes. These are point estimate evaluations. We didn't do a detailed classic uncertainty analysis. We did do sensitivity studies.

VICE CHAIRMAN BONACA: So how -- I mean look at the difference -- 255, 259. You're talking about four tenths to the minus seven difference, and this comes from a point calculation which can be off by a factor of two.

MR. LEE: True. We didn't do -- because this wasn't a risk-informed submittal, we didn't do a classical uncertainty analysis. We believe the uncertainty analysis would be similar to the uncertainty shown in NUREG 1150, and we don't believe that the Brunswick PSA has any unique plant features that would change the results from that uncertainty analysis.

MR. KITCHEN: The other point is that when we factor in the SLC boron concentration increase, which we have committed to since the ACRS Subcommittee meeting, with that change, we go from -- and ATWS is a highly weighted accident PSA. When we make that change alone, going from two-pump required success criteria to the one-pump required success criteria, as you can see it reduces the impact.

MR. ROSEN: To what do you attribute the slight increase in the EPU case, in the point estimate?

MR. LEE: The increase in the point estimate is due to some decreased time for available operator actions related to level control. So the decreased time available showed resulted in a slight increase in some human error probabilities.

MR. POWERS: Are we looking at a balancing of negative and positive things? I mean it seems to me you've done some -- you're doing some things stabilizing your grid, which clearly should reduce your risk. At the same time, you're decreasing the opportunities for the period of time available for operator actions, which apparently increases your risk. Is the magnitude of that increase masked by some of the grid stability things that you've done?

MR. KITCHEN: We didn't -- Larry, we didn't credit the --

MR. LEE: No. We did not credit any potential positive impacts by increasing grid stability. Like, for example, decreasing the loss of off-site power initiating event. The only one we -- in sensitivity studies, we took credit for the SLIC modification. We also did a sensitivity where we increased the turbine trip frequency by ten percent to account for any uncertainties in any potential increases in SCRAMs due to Plant modifications or potential decreases in SCRAM margins.

MR. KRESS: What is your conditional late containment failure probability?

MR. KITCHEN: I'm sorry?

MR. KRESS: The conditional late containment failure probability? It's a Mark 1 containment. Usually those things are done around 0.8.

MR. LEE: We didn't recalculate the late containment failure probability for the Level 2 analysis.

MR. KRESS: Well, it probably doesn't impact it except it gives you a late containment failure frequency which is basically equivalent to your CDF, which would make it like two times ten to the minus five. I just wondered if that gives anybody any pause for reflection other than me. Late containment failures we know of impact on either. I recognize that Reg Guide 1.174 doesn't talk about late containment failures, which is one of the things I think's wrong with it. But I just wondered if the staff looked at that and gave them any pause for reflection at all?

MR. WALLIS: Are you going to ask the staff that?

MR. KRESS: Pardon?

MR. WALLIS: Are you going to ask the staff that when they --

MR. KRESS: Well, I think that's a staff question. Did they think about that and did it give them any serious heartburn at all?

MR. HARRISON: If I can -- I think the answer is fairly quick. This is Donnie Harrison from the PRA branch, and I'll give you two parts to the answer. The first one is we didn't look at it. The second part is that it is something that's being thought about, but it's not in the guidance now. And it's something that the staff does need to think about. Under what conditions would you really want to look at the late containment failure probability? And I think unlike South Texas, on their exemption, there was a case where we didn't want them having some systems that only come into play on the late containment getting dropped. So there will be cases where that is looked at, but it's something I think the staff needs to think through completely to come up with some guidance on when you would apply it and when you wouldn't.

MR. KRESS: That might be some sort of update to the Reg Guide 1.174 at some time maybe?

MR. HARRISON: I'm not involved in that, but I would hope in that revision they think about that type of thing. And I'll take that back to them.

MR. KRESS: Okay.

MR. WALLIS: So let's just clarify. That's since we met you a week ago, you have agreed with the staff that you will install the SLIC modification. That's part of your application now?

MR. KITCHEN: Yes, sir; that's correct.

MR. WALLIS: Okay.

MR. KITCHEN: And installed in such a way that it results in single-pump --

MR. WALLIS: Single pump, right.

MR. KITCHEN: -- success criteria.

MR. WALLIS: Thank you.

MR. KITCHEN: This concludes the presentation that we have prepared.

MR. WALLIS: Any more questions for the presenters? I'd like to move on to the staff presentation. Thank you very much.

MR. MARSH: I'm going to go ahead and get started while people are shuffling around. Good morning. My name is Tad Marsh, and I'm the Acting Deputy Director of the Division of Licensing Project Management in NRR. We are here today to summarize our review for the extended power uprate application for the Brunswick units.

The staff has conducted a thorough review of the Brunswick Plant and those areas potentially affected by the power uprate, with the focus of our review --

CHAIRMAN APOSTOLAKIS: Excuse me. Who is speaking?

MR. MARSH: Oh, I'm sorry.

CHAIRMAN APOSTOLAKIS: Dr. Wallis, are you going to need extra time?

MR. WALLIS: I'm not taking any time. The staff is taking the time. I think the staff may need some extra time, because --

CHAIRMAN APOSTOLAKIS: We're supposed to finish at 10:30.

MR. WALLIS: That's right.

CHAIRMAN APOSTOLAKIS: Twenty minutes is enough time?

MR. WALLIS: Tad Marsh has no -- how much time do you need?

MR. CARUSO: We had assumed that we would have an hour.

MR. WALLIS: No, you weren't even allowed an hour originally.

MR. CARUSO: Forty-five minutes.

MR. WALLIS: Can you do it in a half an hour?

MR. CARUSO: We can give our presentation in a half an hour.

MR. WALLIS: The problem is our colleagues asking questions.

CHAIRMAN APOSTOLAKIS: Well, the whole idea is --

MR. MARSH: We probably need a half an hour to go through our slides. If there's no questions, we can go through it --

PARTICIPANT: If we're not going to ask questions, there's no point having a meeting.

CHAIRMAN APOSTOLAKIS: No, no, no. We should ask questions.

MR. CARUSO: We'll try to be efficient and effective.

CHAIRMAN APOSTOLAKIS: Huh?

MR. CARUSO: We'll try to be efficient and effective.

CHAIRMAN APOSTOLAKIS: Well, the best way is to actually skip some slides. Can you do that sitting there?

MR. CARUSO: We'll try. We'll try to go through --

CHAIRMAN APOSTOLAKIS: Or does he have to go through five letters of review?

MR. MARSH: Why don't we --

MR. WALLIS: Maybe, Tad, we could cut down your introduction.

MR. MARSH: That would be fine, but I do want to make some comments.

MR. WALLIS: Sure, certainly.

MR. MARSH: Okay.

MR. WALLIS: So let's try to --

MR. MARSH: I do have some things I need to say. Okay. I'll skip some of the boilerplate, but I do want to concentrate on the large transient testing statement. And I want to reemphasize what I said earlier regarding the large transient testing. And as you know, the licensees have proposed not to conduct such tests for EPUs. And as I said earlier, the Director of the Office of Nuclear Reactor Regulation has tasked the staff to develop generic guidelines for testing programs, including power uprates. And this effort will formulate guidance to determine whether or not such tests are to be conducted, including the large transient tests.

During previous meetings with power uprates, the Committee has commented that such guidance should be developed to provide the staff, licensees and the public with clear criteria for evaluating these requests related to testing. We intend to provide the plan to the Office Director by May 31, 2002, and we will of course keep the Committee involved in those discussions.

I want to emphasize, though, that the charge from the Office Director was not to require tests, it was to develop criteria such that the staff can evaluate in some more routine manner whether they should be conducted or not. The charge was also not citing that there was any immediate safety concerns absent those tests. So I wanted to emphasize that.

Now, as I said, we'll be glad to discuss this with you further, but because of the nature of the issue and how it arose and how it's being pursued, we should probably conduct it in a manner different than having a public meeting. And we'd be glad to do that with you and for you at your choosing.

With that, Mr. Chairman, I'll turn it over to Brenda who's going to go through our presentation.

MR. ROSEN: The difficulty I have with that is that the Panel's recommendations may or may not be applied retrospectively, and then that -- I think the Committee needs to understand that point.

MR. MARSH: Yes. What could I say? The Office Director, in transmitting this thing to Brian Sheron and asking him to develop criteria said to use the normal process for deciding whether this should be back-fit or not. It said to use your budgeting process in terms of laying out the time frame period to be done and the endorsement of the Panel's recommendation. The Panel's recommendation itself was to develop the criteria, as opposed to require testing. So there was not an endorsement to require testing, rather to develop the criteria. And there was no criticism specifically of the final judgment that has been made in these past cases; rather it was the process by which the decision was made.

MR. ROSEN: Try to make this clear. If the Panel's recommendations are accepted and ultimately criteria are developed that would apply to Brunswick and require large transient testing, how would that end up being applied to Brunswick?

MR. MARSH: We would have to go through a 50.109 process. We would have to go through a back-fit evaluation to decide whether to change the licensing basis for this Plant, unless there's an adequate protection issue or there's a compliance issue. But we have to go through --

MR. WALLIS: Is this assuming that they've already been given the license?

MR. MARSH: Yes. Yes.

MR. WALLIS: But suppose the license has not been modified by then, what do you do?

MR. MARSH: As I said earlier, if the license were not, then it would have to be -- the outcome would depend upon what the evaluation said. If you haven't issued the license yet, then you could theoretically apply that judgment in a forward manner as opposed to a backward manner.

MR. WALLIS: Does that answer your question?

MR. ROSEN: Yes, that answers it.

MR. MARSH: Let me just -- we're on difficult grounds here because of the nature of the issue and the nature of how it arose. I want to just call your attention to the memo that you have before you and the safety perspective that was embodied in that Panel recommendation. I think that's an important element, and it was an important characterization from the Office Director to the Associate Director in terms of the timing of how this thing should be developed. There was no urgency conveyed.

And those are my statements, Mr. Chairman. I'd like to turn it over to Brenda Mozafari to continue.

MS. MOZAFARI: Okay. My name is Brenda Mozafari. I am the Project Manager for the Brunswick review. I'm going to skip over the overview, just make a few comments to the effect that they provided the application last August and for the most part it follows ELTR 1 and 2. Exceptions were noted in their application. It is not a risk-informed submittal, and it did base a lot of issues in their submittal on previously accepted aspects of previous EPUs.

Now, I just show -- just so that you can see, there were reviewers and reviews done in all these areas, and those you saw reflected in the safety evaluation. But we tried in this presentation, albeit a little shortened, and it was presented during the Subcommittee meeting, but we tried to focus on some aspects of the staff review and certain areas that the ACRS seemed to have some potential added interest. So with that, I'd like to turn it over to the Chief of the Reactor Systems and Fuels Group of NRR, Ralph Caruso.

MR. CARUSO: Since my boss is sitting here, I should explain that I'm not the Chief of the Reactor Systems, Brenda.

MS. MOZAFARI: Oh, excuse me.

MR. CARUSO: I'm only the --

MS. MOZAFARI: Section Chief.

MR. CARUSO: I'm only the Section Chief of the BWR Nuclear Performance Section.

MS. MOZAFARI: I promoted you.

(Laughter.)

MR. CARUSO: This is not the moment for a coup.

(Laughter.)

What I wanted to talk to you about, and I wouldn't be here -- the reason I'm here is that there's an issue that keeps coming up during these discussions with the Committee and involves the applicability of the analytical methods that are used in doing these power uprates. And I would like to discuss -- start the discussion this morning with a review of this issue and a restatement of discussions that we've had in the past on code applicability.

This is the fourth significant BWR power uprate that we've done: Duane Arnold, Dresden, Quad Cities, Clinton and Brunswick. And I wanted to describe to you today code applicability. I want to discuss code applicability and how we assure that the codes are used appropriately.

I'd like to open first with a discussion of our review scope. How do we decide to review and to look at what we review? This point in the process we are gaining most of our -- making most of our review decisions based on experience from prior reviews, the three that we've done so far. Now we've got a fourth. They give us a lot of experience. They give us a lot of ideas about what to look for in the future.

We have some guidance documents, we have a Standard Review Plan, we have Reg Guides, and we have the topical reports that are used to -- that describe the approved methodologies. We use those guidance documents as well as -- as far as they go.

MR. WALLIS: Now this SRP is a general SRP, it's not for uprates.

MR. CARUSO: This is not for uprates, but realize that the SRP -- it's a general SRP. It was designed originally to license these plants, so it includes all the areas that would normally be considered if you were going to relicense this Plant, start from zero. And therefore, theoretically, it should be applicable to reviews for power uprates. So we use that guidance in the SRP and in the regulatory guides.

We are also doing, simultaneously with these power uprates, other licensing actions. We're doing tech spec amendments, we're doing topical report reviews, we're doing lots of other licensing actions, and we learn from them. We have information from them that we consider.

Fourth, we look at operating experience and feedback from the field. We get licensee event reports, we get deficiency reports from licensees. All that information is considered. And, finally, all this information is put together by knowledgeable people, people that are paid to do this job and exercise their judgment to decide what's important and what's not important.

So this is where we get the idea about what to review and what not to review. And you should realize that what we don't review is a lot. The vast overwhelming majority of the information that's developed for these power uprates is not reviewed by the staff. GE has 40 people working on each power uprate. Licensees have probably another 100. I have three people. I can't review everything they do. I can't even review a significant fraction of what they do. So I have to make a choice.

Now, one of the issues that's come up is how do I know the codes are the right codes to use? Once again, this is judgment, but there's actually a bit of a basis to this. This is a BWR and the BWR methods have been applied across the entire BWR range, from probably Big Rock Point all the way up to Grand Gulf. And the power uprates that we've seen so far have all been within the range of applicability for which there are already plants operating at those sort of power levels and power densities. So these codes are not being applied outside a range of applicability for which they're already in use right now.

MR. WALLIS: I guess a question that several of us raised was, yes, it's an approved code, but you know that how you use the code can make a difference to the answer. So you have to worry about how the code is used.

MR. CARUSO: That's in my second slide. I'll get to that in a second.

The second part of this was we're not using any new codes. There was a big flap about power uprates about eight years ago at Maine Yankee because someone decided to use -- among other things, a licensee decided to use a new code for a power uprate, and it hadn't been well-validated. We're not using new codes for these power uprates. They've been in existence for a while, and they're mature. So there's not a Maine Yankee scenario here.

In addition, even though the codes have been around for a while, GE has been making modifications to them continuously. We recently completed a review of a change to the SAFER/GESTER, we've looked at the ODYSY code, and we have ongoing experience with TRAC-G. We completed a review for

AOOs about a year that we discussed with the Committee. So the staff has kept in touch with these codes and these methodologies.

Now, I'd like to go on to the question of how do we know that they're being used appropriately? And I'll start by asserting that the vendors use the codes rigorously. The limits for using the methods are described in topical reports. For GE, there's a topical report known as GESTAR. It's a massive document. It describes in intricate detail how to do the calculations. GE takes these limits from the topical reports and it develops procedures so that it can do production calculations. And that's an important phrase -- production calculations.

These production calculations are done by knowledgeable engineers, they're done in accordance with written procedures. They have to be done that way in order for them to be done efficiently. And those procedures are checked by internal quality assurance people in GE, reviewed by several levels of management, they're attached to a large Appendix B quality assurance program, they're reviewed by licensees who have a vested interest in making sure they're done properly, and the inputs are controlled. GE has a central database. The inputs are also checked by licensees. So there are a lot of controls on the use of these codes to prevent them from being used too creatively.

MR. SIEBER: It's my impression that GE does all the calculations necessary for these kinds of analyses with the same group.

MR. CARUSO: Yes.

MR. SIEBER: And that -- for all BWRs? And that licensees don't do any of these calculations independent of General Electric. Is that true?

MR. CARUSO: I don't know. You're talking -- that's probably going to a plant-specific issue. There may be some licensees that do some containment calculations of their own, for example.

MR. SIEBER: I accept that.

MR. CARUSO: The fuel calculations, though, I believe are done by the fuel vendors, and I don't know of the other -- how much technology transfer goes on between the other vendors, but I believe GE does not do much, if any.

MR. SIEBER: Okay.

MR. CARUSO: I'd have to ask them, but I believe they don't do it.

MR. WALLIS: It does mean that they're very dependent on the results prepared by GE. They are the source of the numbers, which are quoted and approved and all that. Nobody else is.

MR. CARUSO: Well, GE is responsible for the results, but they depend on inputs that are received from the licensees about the plant configuration.

MR. WALLIS: Right.

MR. CARUSO: About the operating procedures, about the assumptions for operator action times. So there is -- it's not all done by GE in a black box; the licensees interact with them.

MR. ROSEN: Accepting that point, could we have the GE guy tell us how much is done by the utilities --

MR. CARUSO: Fran?

MR. ROSEN: -- in Brunswick, in particular, but more generally if you can.

MR. BULGER: This is Fran Bulger from GE. We have made these codes that are used in these licensing analyses available to the licensees, and most all of them have, at least to some extent, some of the codes. At least -- most all have the core design codes, and many have the transient analysis codes. A number of them actually have done in-house training with some of these licensing codes, so they try to see if they can reproduce some of the GE values.

We've held training up in Raleigh with some of the CP&L staff to get into some more of the details of the transient codes. The CP&L has a number of the GE codes. A number of the utilities send their staffs to GE and do actually perform some of the licensing analysis at our site.

MR. CARUSO: So you see that the licensees and GE work together on this. This is not something that's done by GE in a vacuum.

MR. WALLIS: But there is no independent calculation made by somebody else.

MR. CARUSO: That is correct.

MR. SIEBER: It was my impression --

MR. CARUSO: At least not by the staff.

MR. SIEBER: -- that if the licensee, on its own volition, wanted to perform the calculations and make those calculations the record calculations for the plant, they would have to have all this infrastructure that GESTAR discusses, including an approved topical that describes how they will do the calculations.

MR. CARUSO: That's correct.

MR. SIEBER: And that's a big hurdle to

jump through.

MR. CARUSO: I believe at this point that we have not approved the use of any of the GE methods by any licensees. Is that correct, Fran?

MR. BULGER: That's not correct. Southern Nuclear is approved to use GE methods.

MR. CARUSO: Okay.

MR. SIEBER: That's pretty helpful.

MR. CARUSO: That's something I did not know.

MR. BULGER: That's the only utility that is.

MR. CARUSO: Is that the only utility?

MR. BULGER: For the GE methods. Excellon had been using some of the GE methods to do slow transient analysis and some of the core design work. Recently they've decided to contract that out to GE.

MR. ROSEN: This is, of course, not true in the PWR side.

MR. CARUSO: That's correct. That's why I'm careful about saying this.

MR. ROSEN: Numerous PWR utilities do their own calculations and have approved topicals, as far as I know.

MR. CARUSO: That's correct.

MR. SIEBER: Some do, some don't.

MR. ROSEN: Some do, some don't, but there are quite a few that do have approved topicals and do their own calculations.

MR. DRESSER: This is Tom Dresser with CP&L. Though CP&L does not do licensing calculations independently from GE, we do, as part of our own review and oversight program, we do quite a bit of independent calculations. We have to access to some of the codes from GENNE, and we also have independent neutronic methodology. So it's -- we do, in addition to oversight of the vendor, we do alternate calculations for our own review purposes.

MR. CARUSO: So the licensees -- in this case, this licensee does do some independent checks, independent calculations, but the staff does not for these normal -- for these sort of applications where a licensee or GE is using an approved methodology in an appropriate way, in a way that is not, as I put it, creative.

MR. RANSOM: Ralph, I think you said that they have made some changes to these codes?

MR. CARUSO: They make changes on a periodic basis, yes.

MR. RANSOM: Have you looked at their

review procedure or quality control or quality assurance procedures, I guess, to assure that these changes do not change past results?

MR. CARUSO: The changes that I was talking about have been reviewed by the staff. They submit a revision to the topical report, and we review that, and we assure that the change does not -- well, it usually affects the results in some way, but we assure that it's an appropriate change, that it's justified and documented and it has a basis.

And then my last two items here we've been doing audits of these calculations as part of these power uprates, where we will go to GE Wilmington or GE San Jose and we have a team of five people who actually look at the detailed design record files for selected calculations. Based on their judgment, they decide, "I want to go look at LOCA this week. I want to look at ATWS next week. Next time I want to look at Standby Liquid Control System."

MR. RANSOM: I guess my concern was that they have a procedure in place such that someone cannot simply put in an ad hoc change that a particular individual wants.

MR. CARUSO: It's my understanding that the proceduralization of the analysis process is done to prevent that from occurring. That's a major sort of change, and they don't like to do that.

MR. SIEBER: It's my understanding that the vast majority of the changes are basically corrections that have somehow or other been discovered through the use of the codes, and they're required to be submitted annually.

MR. WALLIS: I'm going to be in great trouble with my Chairman if we don't proceed.

MR. CARUSO: I'm sorry I'm taking so long. I'm just about done here. This has been philosophy. Zena is going to talk about two areas where during our review we actually did identify some problems and pointing out the value of doing these audits and doing them in a targeted fashion. And she's going to explain to you what she found.

MS. ABDULLAHI: Good morning. My name is Zena Abdullahi, and I'm the Reactor Systems -- one of the Reactor Systems Reviewer for the Brunswick EPU application. I'm going to try to skim through my notes and try to speak fast since we are pressed for time.

In the previous EPU presentation, you asked us to discuss specific areas of review that would give you a sense of our review process.

Therefore, we did decide -- we decided that we will pick up two areas of examples and try to present it to you to show you to the detailed level that sometimes we look into things. We've decided to address today ATWS and Standby Liquid Control.

In the ATWS case, one of the reasons we selected ATWS because it was -- the peak pressure was high. The PUSAR reported a peak pressure of 1492 psig compared to 1500. And we decided, therefore, to look further and to check since it's a two-unit application and the units have many similarities but they do have also some differences, including bypass capacities and the orifice sizes of the units.

We then decided for the ATWS to make sure that, at least in terms of peak pressure, that the two units the most limiting is used in terms of plant condition. And we found out that in fact, yes, the analyses were based on Unit 1, which had a bypass capacity of about, I think, 20.6 percent. This is the turbine bypass capacity. And that for Unit 2, in fact, which has a larger bypass capacity of 69.6 percent for the EPU rated thermal power, that for a specific event, called the pressure regulator failure open, that Unit is in fact more bounding.

The reason the Unit would be more bounding would be that you would have a failure of the pressure regulator to maximum demand. It would open faster, it would steam out through the bypasses, and the unit that actually depressurizes through the lowest -- pressurizes earlier would be the one that would have MSIV close earlier. And, as such, then you would have the pressure go up, the boards collapse, the power go up, and that would be the unit that in terms of peak pressure would be more bounding.

We have asked the Licensee, and they have confirmed that, yes, this unit -- the analyses were based on Unit 1 in which the loop and the MSIV closure were the bounding case, and they reanalyzed the Unit 2 using the Unit 2 bypass capacity. However, they do actually use plant-specific parameters in order to try to reduce the conservatism. And one of the things that they have done is they changed the pressure -- the SRV set point, and instead of using the GE value of 44 psig, they used three percent tolerance, which is the plant-specific value, in which case that comes to 34 psig. Then you would end up having ten valves popping open earlier, which will help you reduce the peak pressure.

And as a result, the peak pressure that -- it basically compensates for the impact that you would have got from the larger bypass capacity. And from that they did in fact come up with a lower peak pressure of 1487 as opposed to 1492. However, the staff did go through the details officially that we're comfortable with the value that they came up with and can say that, yes, they do meet ATWS, and the peak pressure is acceptable as long as it's below the 1500.

I'll go faster. With the --

MR. POWERS: Let me ask a question about your calculation.

MS. ABDULLAHI: Yes.

MR. POWERS: You indicate that they changed the set point away from that recommended by General Electric. Is there any possibility of error in making those set points?

MS. ABDULLAHI: You mean the tolerance value or error in -- for the set points, yes. I mean if set point drift goes up, their ATWS analysis would not work. But the GE value of 44 psig was based on certain type of valve that they knew had a propensity for high drift.

MR. POWERS: What I'm asking you, or I'll get around to asking, I guess, is that do you do a calculation and say, "Oh, what if by mistake the put their set points in incorrectly?"

MS. ABDULLAHI: Oh, you mean the numbers.

MR. POWERS: Yes.

MS. ABDULLAHI: Well, we are relying on their analysis. What we actually check is key parameters, limiting conditions, limiting components out of service. We look more on the sequence, and we look if the result makes sense and if there's sufficient margin. But we have not inputted the numbers.

Having said that, from the audit point of view, I don't see that it's such a far-fetched thing that -- the way we do it we look at the plant-specific and then we also look at GE methodology. And I don't see that it's not possible that at one point we would actually go to that degree of some other audit, but we haven't done it this way.

MR. POWERS: So the impression I'm getting is that you look at what they have done, and you say is that acceptable, but you don't do what my colleague here is suggesting is you might say, "Why don't you go back and make some other assumption?"

MR. CARUSO: We don't do our own sensitivity studies to look at the potential errors that might be made in input values by licensees or by GE, no.

MR. MARSH: Just a reminder these values are technical specifications, and they're, of course, bound by those, and they have LERs and other reporting criteria should they find these out of specification.

MS. ABDULLAHI: I think I have time to say a few things about the SLC.

MR. WALLIS: I think we're all interested in that one.

MS. ABDULLAHI: Oh, I see.

MR. POWERS: It's not for lack of interest.

MS. ABDULLAHI: Maybe I should skip it. All right. The SLC issue, the PUSAR did not contain an SLC relief valve margin evaluation. And the objective for us presenting this to you is to tell you that we do not only look most cases at only what is discussed in the ELTR 1 and 2. If there is an information notice or other information that would tell us some issue, we would actually carry it through, because we would think what would be the impact for the EPU, and then we would look into it. And this is the case that we have done that.

In this particular case, the concern is that the SLC System would -- okay, what we would like to know is whether the SLC System could inject into the reactor at the assumed time, in the analytically assumed time, based on the predicted pressure and without lifting of the SLC relief valve. Because there's a set point in which the SLC relief valve will lift, and if the pressure in the ATWS analysis is at some point, then you might end up getting the relief valve lifting.

And in the initial we asked the Licensee to do that evaluations, and in the initial evaluation, the Licensee did come back and say that, "Well, the value -- we have actually no margin." And as a result of it, they went again and recalculated their two-pump system losses. The original system losses was based on 1984 GE evaluation. So they substituted that with their own system loss test. They also calculated the plant-specific using plant-specific elevation head calculations, and then they came up with a better margin. And it's a positive value, but it was still small.

The staff could not, at that point -- the staff accepted it for several reasons. One reason is the value is positive, and the margin belongs to the licensee. However, the staff felt that it was small and had several discussions, and the Licensee did recognize it. The Licensee did recognize it, and they actually are going through with their own system upgrades. And as a result of that, they will -- informed us, "Yes, we will increase the margin by changing out the valves." However, it's their own call to make. We can only encourage and support. And we have been told that, yes, they are making it. We have a letter that they sent us in which they told that, "We have already ordered the valve change-out and we will change."

MR. SIEBER: Actually, restructuring SLC operations to one pump is a benefit from the standpoint of margin.

MS. ABDULLAHI: Yes, it is, because if, for instance -- let me first make another point of view addition to that. Even if they go to one-pump, single-valve success criteria and they will be able to shut down the reactor, the Licensee intends to stop both pumps, because they do not want to change their EOPs or retrain their operators.

MR. SIEBER: On the other hand, that means there's greater chance that you'll lift a relief valve with two pumps.

MS. ABDULLAHI: Exactly. What would happen is if one pump can do the job and you stop both pumps, even if the relief valve pops open and recycles back to the tag, you still would put in enough boron concentration to shut down the reactor, probably more than usual. So we have accepted it.

However, there are two license conditions that are in the easy application. And the two license conditions basically deal with the fact that when they load the second batch of GE14 fuel, they would need to increase the boron concentration, and as such we would like to have an amendment request submitted in advance before they do the load -- load in the GE14. So there's that amendment request license condition.

Secondly, the Licensee had decided to commit to the single-pumps with valve success criteria in a sense of having a sufficient boron concentration to be able to achieve shutdown using one system. And that is also a license condition for the application. Thank you very much.

MR. WALLIS: Now, I'm trying to see what would the ACRS might say about this, the letter. You have agreed with the Licensee, it seems, since our last meeting, they will install these modifications. So this -- first we need to say less to encourage this. Has it already happened?

MS. MOZAFARI: It's happened.

MR. WALLIS: Okay. Thank you.

MR. SIEBER: Go ahead with your conclusions. I have something to say after you're done.

MS. MOZAFARI: Okay.

MS. ABDULLAHI: We have reviewed the Licensee's application for EPU, and we have concluded that -- from all the reviews, we have concluded that BSEP units can be operated safely to 2923 megawatt thermal, and the Licensee's analysis has been demonstrated it can support this uprate.

MR. LEITCH: I take it by that statement, then, you have no problem with allowing credit for the five pounds containment pressure?

MS. ABDULLAHI: I am not --

MS. MOZAFARI: She's the reactor --

MR. MARSH: That's next. That's not this one -- that's not reactor systems, that's containment systems.

MR. WALLIS: It's very similar to what was granted at another plant.

MS. MOZAFARI: Richard? Richard can speak to that, Richard Lobel.

MR. LOBEL: This is Richard Lobel from Plant Systems Branch. No, we don't have a problem with it. It was considered in the review. It's a small fraction of the total containment pressure which was calculated to be conservatively low. And what we've done on this review is consistent with what we've done in other reviews and what we've discussed with ACRS in the past.

MR. ROSEN: My comment is that this is an excellent piece of work, and the reviews that have been done have found important things, and I want to commend you on that. One of the concerns of the Committee has been one central aspect of core design for these uprates and the limited amount of review we actually do. You described you do fairly little, but we do only a piece of what we could do is small also. So it seems to me that I derive considerable comfort from the fact that you are out looking at these analyses, but this a bad news/good news story. The good news is you're out looking, the bad news is you found some substantive things that were wrong. So my encouragement is to keep looking and to make sure that you do -- I think this Committee has made this point in the past, that these audits that you do have great value and should be continued.

MR. CARUSO: For the BWRs, because of the interest, because of the large amount of the power uprate, we do intend to do that. And we do intend to do it on a focused basis. We don't intend to look at the things that are listed in the guidance documents, because everyone knows that's what we're going to look at. So those are the ones that are always right. We're looking at the things that aren't -- we're trying to look at the things that aren't listed in the guidance documents, and we get hints about where to look by --

MR. MARSH: Operational experience plus any types of other evaluations that come up in the safety evaluations.

MR. CARUSO: By thinking about these things.

MR. MARSH: Right. I did want to point out that in terms of the SLIC review they've just gone through, this was a topic that came up as part of an operational experience. So operational experience vectored us into, and that's why we focus on this topic, which is building on Ralph's thought of that being a source of staff scope concerns.

MR. CARUSO: We look at as much as we need to look at to make a decision. And we're comfortable with the level of review at this point.

MR. MARSH: Ralph mentioned three staff. I want to say something about three staff. If the

Agency felt like there was an operational experience that warranted more staff to be devoted to this type of audit or confirmatory calculations, the Agency would devote the staff that it needed to do these things. So I want you to understand which comes first, the chicken or the egg. Ralph has three staff because that's what we think is needed at this point. If more staff were needed, we would go through a budget process and decide whether it were needed and devote more staff to it. So we are driven in resources by the safety concerns that these staff are looking at.

MR. WALLIS: So somebody made the decision that for all these uprates having to do with GE reactors, that the ELTR 1 and 2 and all that were so good that you didn't really need any kind of work to check those.

MR. MARSH: Well, you've heard some independent calculations beyond ELTR 1. You've heard Rich talk about some containment calculations which he has done beyond what the ELTR 1 leads you to do. The SLIC work that's here is not -- the SLIC doesn't tell Zena to do the type of reviews that she does. This is beyond -- this is -- the ELTR doesn't tell Ralph what to do in audits.

MR. CARUSO: Interestingly enough, in the SLIC case, it's not a question of the methodology changing, it's a matter of what point they pick on the curve to assume as the peak pressure. And there were some assumptions made about when the operators would start the SLIC system and the pressure at that point. And that's not a calculational issue, that's a much bigger, what we would call, methodology issue.

So doing an independent calculation would not have told us anything in the SLIC area. We had to look at what they did with the numbers and what judgments they made with the numbers. And we looked at the operating experience and what the operating experience told us about the assumptions. So you have to fit them all together. That's why you need somebody, a person who's knowledgeable and can make a judgment about what's necessary.

MR. MARSH: The importance of Ralph's audits going beyond, looking over the fence, can't be understated too.

MS. MOZAFARI: Right.

MR. MARSH: He goes beyond what you would expect to be looking at to see whether those other areas that are of concern, and if concerns were found in that area, that would widen the staff's scope depending upon the safety significance. And, also, we rely on Part 21, we rely on licensee event reports, we rely on a lot of elements to determine our scope.

MR. CARUSO: In the area of core design, we have been spending I believe Ed Kendrick, who's here, did look at some core design issues during Brunswick review or during one of the earlier ones. So we have been looking a little bit at the core design, but in a lot of cases we just don't think it's worthwhile to look at calculations that have been done on a routine basis for a long period of time using well-established methodologies. It's just not worthwhile.

MR. WALLIS: Ralph, can we move quickly through the rest of the slides?

MR. CARUSO: I'm sorry, excuse me.

MS. MOZAFARI: Ralph's going to cover the appendix, our evaluation from the fuel --

MR. CARUSO: I don't have the slide in front of me, so I'm going to have to read from the --

MR. WALLIS: I think we've all read it by now.

MR. CARUSO: We've seen this?

CHAIRMAN APOSTOLAKIS: Yes. We've read it, and the last bullet is your conclusion.

MR. CARUSO: I'll make one more point about this. There was a concern about the increase in the temperature from less than 1200 to close to 1500. It's our understanding that the less than 1200 number was not actually a calculation but was an estimate. So we would say it's not really fair to make a comparison between an estimate and a calculation and say the value went up by 300 degrees.

And I agree with the points that Dan Pappone made. Those are reasonable assumptions made, using a reasonable code, and they came up with an answer that is reasonable, and we accept that. We don't see any reason to redo the calculation.

MR. WALLIS: Okay. Thank you.

MR. CARUSO: Thank you.

MR. MARSH: Okay. Mr. Chairman, would you like us to go through the mechanical engineering presentation? Would you like us to focus on something?

MR. WALLIS: I think the bottom line is that you think is everything fine.

MR. CARUSO: Yes.

MS. MOZAFARI: That's the bottom line. So you're not interested in hearing it? That's fine.

MR. CARUSO: Okay.

MR. WALLIS: So you believe Dan Pappone's analysis about acoustic loads? You're happy about the acoustic loads issue?

MR. MANOLY: Yes. I just want to correct -- this is Kamal Manoly from the Mechanical Branch. Apparently, there was some misunderstanding about the magnitude of the loads from the pipe break, and they're dependence on the pressure and the temperature in the line and not the flow rate.

MR. WALLIS: Right. It depends on the pressure in the line mostly, isn't it, and not the flow rate. Yes.

MR. MANOLY: And the temperature.

MR. WALLIS: Right.

MR. MANOLY: And I looked at the tables -- my lead reviewer is not here this week, but I looked at the tables of the results of the difference in pressure. Slight, very slight increases in pressure.

VICE CHAIRMAN BONACA: Please speak into the microphone.

MR. MANOLY: Yes. There's very slight increases in the pressure, the differences in the internals. So the stresses increased are fairly insignificant.

MR. WALLIS: So you have checked this

point raised by the Subcommittee, and you've come to the conclusion it's not an issue.

MR. MANOLY: Right.

MR. WALLIS: I think that's all we need to know really.

MR. LEITCH: I just have a question about the overall efficiency of the process, and we discussed it a little bit at the Subcommittee meeting. But I suspect that there are going to be a large number, perhaps almost all, of the BWRs in this cube to get power uprate. And it seems to me that this has taken an inordinate amount of time, a very large number of RAIs involved in the process, and I just wonder if we can't learn something from the license renewal process, which seems to be running much more smoothly with a fairly low number of RAIs. Is there a more systematic way in which this type of a review could be conducted?

MR. CARUSO: I believe that for the BWRs --

MR. MARSH: Let me give it a try from here, because I want to answer it globally. I talked a little bit about it at the Subcommittee --

MR. LEITCH: Yes. That was my question was really a global one.

MR. MARSH: Yes, sure. Let me try, Ralph. We are committed -- as you say, we are committed to get to the Commission by March 26 with some effort to try to improve the efficiency and effectiveness of the reviews. And we are going to talk with the Commission on July 10 at a Commission meeting with license renewal. Because they've charged us to look at the license renewal process as they improve their efficiency to see whether we can draw from some of the benefits that they have found in terms of the process. So we are charged to do that. And we hope to meet with you and talk with you about that process before we meet with the Commission; that's our intent.

A couple things. CPPU, the reliance on CPPU as a process will help us in some respects. It will help us in terms of efficiency. The number of RAIs we're looking at that carefully. We're making sure that the scope that we're looking at, how we look at them is the appropriate number, the appropriate number of questions. And I think licensees are learning also as we go through this process for what we are interested in. And they're focusing their submittals on the issues that we have sought through RAIs.

We need to be more efficient. We've spent a great deal of FTE on power uprates last year -- over 11, 11.5 FTE in the licensing area. That's a large number. So we need to be better, and we're committed to doing that, and we're going to be discussing it with you.

MR. LEITCH: Good. Thank you.

MR. WALLIS: Anything else? We've lost our Chairman. I'd like to hand the meeting over to the Vice Chairman.

VICE CHAIRMAN BONACA: Okay.

MR. WALLIS: Thank you very much.

VICE CHAIRMAN BONACA: Any other questions from members? If not, we'll take a recess for 15 minutes. We'll actually get back again, we're kind of late, so maybe at ten after 11.

(Whereupon, the foregoing matter went off the record at 10:57 a.m. and went back on the record at 11:12 a.m.)

VICE CHAIRMAN BONACA: Okay. The meeting is called to order again. We have now the -- the purpose of this meeting is to review the findings and observations of the Expert Panel convened by RES to assess the applicability of the NUREG-1465, accident source term for light water reactors to high burnup and MOX fuels.

Two ACRS members, Dr. Powers and Dr. Kress, were members of this Panel. Therefore, they will not participate in discussions on the potential finding of the Committee, although they are not prohibited from providing the Committee with factual information on the subject.

The staff has not requested a letter on this issue, in part, because the information is quite preliminary. We are running late, so I would like to understand how much time you think you need. I think you have half an hour allotted for the presentation?

MR. SCHAPEROW: Yes. I've got about 16 slides, but it shouldn't take too long.

VICE CHAIRMAN BONACA: So I think we should be able to stay within the hour that we have --

MR. SCHAPEROW: Certainly.

VICE CHAIRMAN BONACA: -- scheduled for the presentation and questions. So with that, I'll introduce Mr. Schaperow?

MR. SCHAPEROW: That's correct.

VICE CHAIRMAN BONACA: Okay.

MR. SCHAPEROW: Thank you for pronouncing it like that. My name is Jason Schaperow. I'm Project Manager for some of the agencies who do accident research. My presentation today will cover a research effort in the area of fission product releases.

The objective of this research was to assess the applicability of the revised fission product source term to high burnup and MOX fuels. The approach we took involved holding a series of Expert Panel meetings. Panel membership included experts who had developed the basis for the original revised source term a number of years ago. At these meetings, the experts suggested source term values for high burnup and MOX fuel, identified source term issues and recommended needed source term research.

The next couple of slides provides the background for this research. First, I would like to briefly review the revised source term. Now, the source term is defined as the fission product release into the containment atmosphere which is available for release to the environment. Now, RES published the revised source term, also known as the alternative source term, and adopted it and called NUREG-1465 back in 1995.

This revised source term is more realistic than an earlier source term called the TID-14844 source term. The revised source term is aerosol except for about five percent of the iodine which is vapor. Now, the TID source term was mainly vapor. Also, the revised source term has a four-phase release, which is broken down as follows: Gap, early in-vessel and ex-vessel release, which is during core concrete interactions, and finally the late in-vessel release from the reactor coolant system. This takes place over several hours. The TID source term, however, is instantaneous at the start of the accident.

Also, the revised source term is actually two source terms: One for a PWR and one for BWR. There's not a lot of difference, but there are a few. The main difference, I believe, is the release timing for the iodine. In the BWR, the iodine release occurs a little later as a result of the BWR's lower power density.

The revised source term is used in a number of regulatory applications. In particular, the first two release phases, basically up to the point of lower head failure, is used for LOCA design basis accident analysis. And I've listed here five ways in which we've used this. It's used to assess doses for the Exclusion Area Boundary, the Low Population Zone and in the control room. It's used for the containment isolation valve closure time requirements, and in this particular use is just used as a start time on the gap release. It's been used in a fashion as an integrated dose of the source term. It's been used to qualify equipment in the containment. It's been used for post-accident shielding, sampling and access. And, finally, it's been used to evaluate the hydrogen generated by radiolytic decomposition of water during an accident. And all four phases of the source term may be used for severe accident risk assessment.

The effect of the revised source term on licensing, as well as the risk impacts, were evaluated in our rebaseline project a few years back. After the rebaselining project, the staff, NRR in particular, developed a rule to allow licensees to implement the revised source term. Now, their baselining analyses identified that there would be a number of safety and cost benefits that would result from implementing the revised source term. And as you can see here, a lot of licensees have opted to voluntarily implement the revised source term. So far NRR has issued license amendments for ten plants and seven more plants in process right now for getting their license amendment.

VICE CHAIRMAN BONACA: Most of -- I mean all of these applications have to do with the first two phases, right?

MR. SCHAPEROW: That's correct. They have to do with the first two phases.

VICE CHAIRMAN BONACA: The first two phases. Okay. So just gap release and in-vessel.

MR. SCHAPEROW: And early in-vessel.

VICE CHAIRMAN BONACA: Early in-vessel. Okay.

MR. SCHAPEROW: That's correct. The approach we took to assess the applicability of the revised source term for high burnup and MOX fuels involved holding a series of Expert Panel meetings. These meetings were held over the last six months, and in these meetings, the Panel members were requested to judge the applicability of each aspect of the revised source term. If the Panel members judged a particular aspect to not be applicable, then we would request of them to propose an alternative. As part of this effort, Panel members considered recent data from international tests. They discussed physical phenomena extensively that affect the source term and for high burnup and MOX fuels. And also they did quite a bit of work in the area of identifying and prioritizing source term research.

MR. WALLIS: Was this a PIRT sort of

exercise?

MR. SCHAPEROW: We didn't go through the PIRT process. We identified phenomena and ranked them. It was an expert elicitation, but we did -- there were extensive discussions of physical phenomena that would affect the source term for high burnup and MOX.

This slides lists the Panel members and the other main players in this research. And as the Chairman mentioned, two of the ACRS members were involved in this work.

MR. WALLIS: Kress is one of those international consultants?

MR. LEITCH: Yes. He's from the country of Tennessee.

(Laughter.)

MR. KRESS: I'm not supposed to say anything. I've got a conflict of interest.

MR. SCHAPEROW: For the experts to assess the applicability of the revised source term for high burnup fuel, it was necessary to specify certain parameters, such as how high of a burnup we are talking about. This is the decision we made. We decided to go ahead with a Panel assessment based on a maximum assembly burnup of 75 gigawatt days per ton.

Currently, the maximum assembly burnup is on the order of about 60 gigawatt days per ton. We also decided to go ahead with the assessment based on a core average burnup of about 50 gigawatt days per ton. For PWR, the assessment was based on cladding made of Zirlo, and for BWR, Zircaloy cladding.

And, finally, the assessment of fission product release fractions, which is part of the overall source term assessment, was based on a low pressure scenario. Now, this minimizes RCS retention and is the same approach that we took in developing the original revised source term.

MR. SHACK: Explain to me the low pressure scenario.

MR. SCHAPEROW: In a low pressure scenario, such as, let's say, a two-inch break, because the pressure is low, and in these scenarios is a fairly direct release path to the environment. There's no recirculation in the system to allow deposition. For example, in a station blackout scenario, the system sits there for a while with water low in the vessel. And so the steam recirculates and fission products deposit throughout the system but in a low pressure scenario as a whole, and it just comes out -- goes out of the --

MR. ROSEN: Low pressure refers to low pressure in the containment.

MR. SCHAPEROW: No, low pressure in the RCS.

MR. SHACK: So any LOCA would be a low pressure scenario.

MR. SCHAPEROW: That's correct. Any LOCA of a size --

MR. SHACK: A big one.

MR. SCHAPEROW: -- to open up a hole so that the fission products could flow right out without having to circulate through the system. A PORV type of LOCA, where the PORV opens and closes, that would basically keep the reactor's coolant system in tact, and the steam would circulate the fission products and it would deposit. So that would maximize deposition. And the types of deposition we're talking about for a low pressure scenario is about 50 percent of the fission products released from the core and deposited in the reactor coolant system. In a high pressure scenario, it could be a lot higher.

MR. SHACK: For those first two stages, you really do retain 50 percent of the stuff.

MR. SCHAPEROW: That's what we believe. That's what the experts believe, excuse me. I was not on the Panel.

MR. WALLIS: Even a large-break LOCA you deposit 50 percent of the stuff? It gets out of the core and deposits somewhere else in the --

MR. SCHAPEROW: I believe so.

MR. WALLIS: Where does it go?

MR. SCHAPEROW: Well, there are structures in the reactor, there's pipe -- mainly reactor structures.

VICE CHAIRMAN BONACA: I think much is in aerosols too, right, inside in some other structures?

MR. WALLIS: I think maybe 50 percent is an expert guess between zero and 100.

MR. SCHAPEROW: Well, a lot of those calculations were actually done quite a number of years ago with a search and code package by Jim Gieseke who's one of our Panel members. We had, I think, about 30 cases that were run for five different plant designs to look at deposition. We really didn't tackle that subject much in these Expert Panel meetings. We really did focus in on the fuel. That's what we're really changing here. In one case, we're letting the burnup go a lot higher; in the other case, we're changing to a mixed oxide fuel.

VICE CHAIRMAN BONACA: But TMI also was a good data point, right? And it was a high pressure scenario. I mean it was a small break, TMI?

MR. TINKLER: TMI was characteristic of those sequences where you would get more deposition --

MR. LEITCH: Charlie, identify yourself.

VICE CHAIRMAN BONACA: And I'm saying the deposition inside was --

MR. TINKLER: Was quite high.

VICE CHAIRMAN BONACA: -- quite high. It was higher than 50 percent.

MR. TINKLER: Jason, if I might, I might point out that --

MR. LEITCH: Charlie, please identify yourself.

MR. TINKLER: Charles Tinkler from RES staff. There is some variability within large LOCAs. The very largest LOCA, if it were a double-ended hot leak break, for example, where it was a direct path out of the vessel, you would get retentions of less than 50 percent. But when this Panel considered large LOCAs, all large LOCAs aren't double-ended hot leak breaks. Cold leak breaks where the path is through the steam generator or back up through the down-comer, you get larger amounts of deposition. And not all large LOCAs are double-end guillotine breaks. So I think it's true to say that the Panel considered LOCAs as a general group and thought that the 50 percent was reasonably --

MR. WALLIS: But if you had a hole in the vessel head, I think most of it would come out.

MR. TINKLER: Which would be pretty close to a double-ended hot leak nozzle rupture too, and there wouldn't be a great deal. You might see retentions in those cases of maybe ten, 20, maybe 25 percent, but, like I said, they're --

MR. KRESS: You have to keep in mind that these are source terms to be used primarily with design basis accidents. They're not to be used for PRA for the whole sequence of accidents. And so you ask yourself what should be in design basis space. Then you go from there to --

VICE CHAIRMAN BONACA: No, 1465 actually allows you to assess variations depending on the scenarios you're addressing, right? I mean I read it recently and it says that the licensees can propose --

MR. KRESS: If they want to justify some different source term --

VICE CHAIRMAN BONACA: Exactly.

MR. KRESS: -- they can --

VICE CHAIRMAN BONACA: They can do that.

So there is a condition that the scenarios for the low pressure used here is not all bounding, it just simply is the most likely scenario you're looking at and you're using it.

MR. SCHAPEROW: The low pressure scenarios were found to be just as -- about as likely as the high pressure scenarios.

VICE CHAIRMAN BONACA: Yes.

MR. SCHAPEROW: So in NUREG 1465, they said, "Well, geez, in that case we're going to go with the retention of the low pressure scenario, because it's conservative."

VICE CHAIRMAN BONACA: It's conservative, that's right.

MR. SCHAPEROW: They tilt it towards conservatism.

VICE CHAIRMAN BONACA: But it doesn't preclude the use of less conservative approach if you can justify it.

MR. SCHAPEROW: That's correct. Actually, I think the regulation in the Regulatory Guide speaks directly to that.

VICE CHAIRMAN BONACA: Exactly that, yes.

MR. SCHAPEROW: Okay. This table, taken directly from the Panel's draft report, shows the

Panel members' recommendations for a PWR. The first row shows the recommendations for the durations of each release phase. For example, the Panel recommended a gap release phase duration of 0.4 hours while the revised source term duration, in parentheses next to it, is 0.5 hours. The Panel's release phase duration recommendations are about the same, or exactly the same in some cases, as the revised source term.

In the cases where not all the experts recommended the same value, the value recommended by each expert was recorded. For example, in the second row, the noble gas row, for the gap release you'll see that there were four values listed there that are ranging from 0.05 to 0.07. For the so-called volatile groups, the noble gases, the halogens and the alkali metals, the release fractions are about the same as the revised source term.

MR. SHACK: Just out or curiosity, were these differences from 1465 due strictly to the high burnup fuel or were they revising 1465 on the fly too?

MR. SCHAPEROW: They thought about both things, because we have recent test data. We've got the French have run a fission product tests and the Japanese have run a couple of fission product tests in the last few weeks. And I'll go into that a little bit. In the next slide, I go into a little more detail what I thought were some of the main points that the Panel raised.

VICE CHAIRMAN BONACA: In fact, it's an important point. This is an important point you're making, Bill. Probably that's the best -- biggest lesson learned from the report is that 1465 may have to be looked at.

MR. SHACK: See, I didn't have a chance to read any of it, because --

VICE CHAIRMAN BONACA: Yes.

MR. SHACK: -- I've been off --

VICE CHAIRMAN BONACA: And I'm saying that it's interesting that it went from eight groups in 1465 to 14 groups here.

MR. SCHAPEROW: Well, the experts believe that we learned something. I think there was general agreement that we could go ahead and break it further down, because there is -- even into these groups, these heavier groups, there is a range of -- I'm sorry, originally we had noble metals group, but the experts felt that the Molybdenum and Technetium releases were a bit higher, and they felt that it would be worthwhile this time to go ahead and break it down.

MR. WALLIS: It's interesting, when they don't know, they like numbers like one percent or one ten-thousandth.

(Laughter.)

I mean the number one or two appears an awful lot.

MR. SCHAPEROW: Yes. Well, there is a lot of uncertainty associated with the last three groups. The last three groups are the ones which are generally released in the smallest amounts. We haven't focused on them in the past, and they generally -- I don't think that they generally have a huge influence on dose, but --

MR. WALLIS: There's no expert who has some data and calculation and can say it's 0.00957 or something like that?

MR. SHACK: I'm sure his computer will say that.

MR. SCHAPEROW: Actually, in the original revised source term, there was a question as to whether we should specify more than one figure. And we did actually go to two significant figures. For example, the halogen release was 0.35, and they said -- it was one of these a five but not a one or a two.

It was a 0.35 but not 0.33.

Now, this slide provides an overview of the results of the Panel assessment for high burnup fuel. Now, the Panel members generally expected the physical and chemical forms to be applicable. Only small changes in the release-phase duration and the release fraction were expected as a result of going to the burnups we talked about.

However, the Panel did identify some issues that were based on recent tests that were independent of burnup. The first issue was the potential for enhanced Tellurium release, and I'll talk about that in my next slide a little more. As I just mentioned, there's also a continued uncertainty in the releases of the heavier elements, the noble metals, the Cerium and Lanthanum groups. Also, recent data does suggest it may be worthwhile to subdivide those three groups into additional groups.

Now, related issues, which the Panel members discussed, which I'd like to talk about briefly, were, as you heard about at this point, BWR power uprates and BWR fuel design.

VICE CHAIRMAN BONACA: One point I would like to make here is just simply this is very clear for them to have -- there are lessons learned for 1465 here, burnup-independent issues. The report doesn't really speak so clearly about that, and I think you want, at some point, to -- the report should say something about 1465 because there are these changes here and they're burnup independent. So it's left a little bit with the open question when I was reading, so what was going to happen to 1465? Is there some lessons learned that is going to be communicated within this report?

MR. SHACK: Fourteen sixty-five Rev 1.

VICE CHAIRMAN BONACA: Yes.

MR. SCHAPEROW: That's a reasonable idea, I think.

VICE CHAIRMAN BONACA: The report doesn't say, doesn't put it this clearly.

MR. SCHAPEROW: The report is just the results of the expert elicitation.

VICE CHAIRMAN BONACA: Understand.

MR. SCHAPEROW: Exactly. And then the research at NRR, I will -- when this is finished we will -- we do have a number of comments in. We're revising the report now.

VICE CHAIRMAN BONACA: Okay.

MR. SCHAPEROW: But that is a good point. Now I'll talk a little bit about the Tellurium issue.

With regard to the Tellurium, the revised source term specifies an early in-vessel release of Tellurium of five percent. This is supported by Oak Ridge tests performed a number of years ago indicating that Tellurium gets sequestered in the tin, and the Zircaloy cladding is not released until a high fraction of the cladding is oxidized. And by high fraction, we're talking numbers about 90, 95 percent cladding oxidation.

MR. WALLIS: What do you mean by "gets sequestered?"

MR. SCHAPEROW: It's get bound up, bound up with the tin.

MR. WALLIS: It gets bound up during the accident or --

MR. KRESS: Tin Telluride tries to escape its way through the cladding.

MR. WALLIS: As it tries to escape it gets caught?

MR. KRESS: Yes.

MR. WALLIS: Things aren't happening too quickly for that?

MR. KRESS: This, of course, is a speculation because the Tellurium was found associated with the tin in the clad in tests at Oak Ridge, and they didn't get a lot of release of the Tellurium which was a surprise because Tellurium is very volatile. So it's a speculation because it was found associated where the tin was, but there was never any determination that it was Tin Telluride.

MR. WALLIS: You'd think if things are happening quickly, it would just escape, it wouldn't have enough time to get caught up with the tin.

MR. KRESS: Well, the reaction could go pretty fast, but these things aren't as fast as you might think, these transients.

VICE CHAIRMAN BONACA: Yes.

MR. WALLIS: It's a diffusion process.

MR. SHACK: Now, would the tendency in modern clads to go lower tin change this at all or are is there still so much tin?

MR. SCHAPEROW: That's one point the Panel raised. They said, "Well, we think we need -- we'll probably need some more research. We may need to run some tests with -- some source term tests with cladding that doesn't have tin in it." This is the M5 cladding if I'm not mistaken.

MR. SHACK: Well, even modern Zircaloy the tin goes with that.

MR. SCHAPEROW: There are some more recent tests that have been conducted in France that indicate that the Celerium release could be larger, could be somewhere to that iodine, on the order of about 30 percent. And so this was a contentious issue among Panel members. We spent quite a bit of time discussing this to see if we could get any sort of -- if any of the Panel members might agree on this, and the answer was no.

MR. ROSEN: You've got two of your own Panel members to get agreement.

MR. SCHAPEROW: Well, this was not a consensus process, but we did want them to discuss it amongst themselves to try to flesh out the issues.

MR. SHACK: Well, except for early in-vessel, there was one rugged holdout. Everybody seemed to line up.

VICE CHAIRMAN BONACA: I think even more striking is the fact that over the four phases you're showing a release of 95 percent, practically all Tellurium being released, while in the original, in 1465, it's only about 25 percent. So that's another big issue that says what's -- because some of the processes by which you see the differences, like for example, late in-vessel has to do with oxygen entry, but that's true also for low-enriched fuel. I mean you have -- in the phase of the accident, you have integration and you have oxygen coming in. So there is a big discrepancy there which is even larger than the five percent to 30 percent. It's really 25 percent to 100 percent that has to be reconciled.

MR. SCHAPEROW: This issue was raised when we originally developed the revised source term. If you look back at the old document, we had a draft of NUREG-1465 ion 1992, and three years later we had a final, and the Celerium release went down. I think, if I recall, it was 15 percent in the draft, and it went down to five percent in the final. So this issue has been hanging around for a little while, but it's been brought to the forefront, as I said, by some of these more recent tests that were conducted in France.

MR. WALLIS: What's the effect of higher burnup? Is it that the fuel is more porous or something?

MR. SCHAPEROW: Break sizes go down, fission products inside the pellets.

MR. WALLIS: So you'd expect more release, generally?

MR. SCHAPEROW: Earlier, earlier. For the volatiles, earlier. For the volatiles, things get out anyway in either case, so we expect to kind of shift things. The gap release phase, which ends when the pellets start releasing fission products, so the gap release ends a little earlier for the high burnup fuel.

I don't think I quite finished this slide. I wanted to mention for the BWRs the Panel members pretty much stuck with Tellurium release in the revised source term. They felt that the Zircaloy fuel channels would tend to limit cladding oxidation. Now, this wasn't a fuel that had Zircaloy cladding, so there was tin, and you also had the Zircaloy fuel channels to limit the oxidation, because the release doesn't occur until the oxidation gets pretty high.

There are two other source term issues related to high burnup that I would like to mention. One is power uprates for BWRs. We had one -- one of our experts said he didn't think we should change anything, he thinks it's okay the way it is, no basis for significant effect. However, at least one other expert said they thought things would be changed, they thought that that flux-profile flattening associated with the power uprates could increase the releases for the outer assemblies.

The second issue I'd like to mention involves BWR. Our NUREG-1465 specifies actually two different source terms: One for BWR and one for PWR. However, the Panel members noted that the characteristics of the more recent BWR fuel rod designs are closer to the PWR fuel rod characteristics. The BWR rods have smaller pellet diameters and thinner clads. So the Panel felt that similar rod designs would tend to result in similar source terms and tending to maybe not be such a big difference between a BWR and a PWR source term.

The Panel also assessed the applicability of the revised source term for MOX fuel. This slides gives the condition that we used for our expert elicitation. We assumed that we're using MOX in a PWR, which is consistent with what has been proposed by Duke, Cogema, Stone & Webster, and that the MOX is distributed fairly uniformly throughout the core. That's what I mean by about half of the core. It's not just all bunched up around the outside or bunched up in the middle.

The typical MOX assembly burnup, and this is meant to represent sort of a maximum, this 42 gigawatt days per ton, the assessment was based on M5 cladding and, again, a low pressure scenario for assessing RCS retention.

MR. SHACK: Now that's a much higher level of MOX than DOE's proposing to use.

MR. SCHAPEROW: That's correct. They're proposing I think it was a maximum of 40. The point here was just to say that it's basically throughout the core, and it's going to experience the same temperatures that the rest of the core would. It sees the same thermal accident, the same heat-up as all the other assemblies.

VICE CHAIRMAN BONACA: For that information on MOX, I mean a lot of the elicitation ended up with N/As because there is not sufficient information to make -- oh, you have that. Okay.

MR. SCHAPEROW: Next slide. This slide provides an overview of the results of the Panel assessment for MOX. Again, physical/chemical forms were not expected to be an issue. The release-phase duration and the more volatile releases -- noble gases, iodine, Cesium -- were expected to be about the same. Same Tellurium issue as for high burnup fuel. Some experts felt that we would have a higher Tellurium release.

One difference, as Mario just pointed out, from the assessment for high burnup fuel is that in this case, for MOX, some of the experts did not recognize release fractions for some of the groups.

In particular, the Barium group on down to the Lanthanum group. And we don't have data, that's the problem. Right now the only data that at least the Panel had available was a test result for Cesium, and the French chose not to show a scale on the y-axis. They wanted to -- they're not ready to give us that information yet, I guess, for whatever reason.

VICE CHAIRMAN BONACA: They don't know.

(Laughter.)

MR. KRESS: The y-axis was the fission product release fraction.

MR. SCHAPEROW: I'm sorry. Thanks, Tom. I just blocked out data. We generally assumed that the top of the axis was a one, because it was Cesium, and we have some idea that Cesium is pretty -- would come out under those conditions.

The Panel also considered what source term research is needed to complete the Panel recommendations, particularly in MOX, and to confirm the other Panel recommendations, the high burnup and MOX source terms. In this slide, I've tried to list -- I've listed the Panel members' recommendations for the highest priority research.

MR. WALLIS: Isn't the most important thing to get some data? Isn't that the most important thing when you have almost no facts to go on? It's all expert judgment.

MR. SCHAPEROW: I think that's -- four of the five research items here are data. The top one is that we have a little bit of recent data which we're validating against right now, the PHEBUS experiments in particular. We've got some calculations with our severe accident codes. The other four are data.

One issue is the air ingress issue, which needs to be addressed at some point.

VICE CHAIRMAN BONACA: The French are doing a lot of work on fuel. I understand we are not participating in some of them.

MR. SCHAPEROW: In the severe accident source term area, they have two programs ongoing: the PHEBUS program, which we are participating in and we do have some data from. The other one is the VERCORS --

VICE CHAIRMAN BONACA: That's right.

MR. SCHAPEROW: -- source term tests, which are based on the Oak Ridge source term tests. I understand that they had requested some of our experts to come over and help them get started, and those are the ones that we haven't gotten the data from. We've asked for it and we're working with them, but --

VICE CHAIRMAN BONACA: We will get the data from them.

MR. SCHAPEROW: Pardon?

VICE CHAIRMAN BONACA: We will get the data.

MR. WALLIS: Do they have several results of VERCORS or is it so complicated that they just run a couple of tests and that's it?

MR. SCHAPEROW: Oh, VERCORS is a small-scale test on the order of a few pellets.

MR. WALLIS: They do a lot of tests, different issues?

MR. SCHAPEROW: A few of them, maybe three a year.

MR. WALLIS: Three a year.

MR. SCHAPEROW: Basically, a take off from what we had done at Oak Ridge.

MR. WALLIS: How do they get high burnup fuel?

MR. SCHAPEROW: I assume they either get it from a test reactor or maybe a lead test assembly. I'm not sure.

MR. KRESS: Some of its BR3 fuel, which is -- some of it was high burnup. They've tested up to

65 gigawatt days per metric ton. So they weren't going to get it out of old reactors.

MR. WALLIS: Well, I think it would be great if you could go beyond this and sort of lay out what needs to be learned and what needs to be done to learn it in a more specific, detailed way. I mean is a few tests going to do the job or not, and do you need ten times as many tests over a bigger range or whatever? Would someone lay out what are the requirements for knowledge here and what needs to be done to get it?

MR. SCHAPEROW: Well, we are thinking about that, and it's going to depend on what burnup levels people want to go to, for one thing. So it's going to be application-dependent in the end. We thought about having some sort of a larger plan, but in the end it's --

MR. WALLIS: Isn't the time for thinking about it over and the time to do something here?

MR. KRESS: These are kind of expensive tests.

MR. WALLIS: Yes. But we're going to be having high burnup fuel and MOX fuel and decisions have to be made about it, so we need to know.

MR. KRESS: But I think the idea was to

leverage as much you can with these tests that have already been run and are continuing to be run.

MR. WALLIS: Otherwise you will be letting people do things and establishing criteria afterwards.

MR. KRESS: Well, we pretty much know what needs to be done.

MR. POWERS: Tom, I don't know why you're so concerned. I understand that high burnup fuel is irrelevant to regulatory decisions.

MR. KRESS: That's the next presentation after lunch. That doesn't have anything to do with this presentation.

MR. WALLIS: It's high priority research but it's unnecessary, is that it? It's irrelevant.

MR. SIEBER: Irrelevant.

MR. KRESS: That's the next presentation.

MR. SCHAPEROW: Finally, a brief status. We got comments from the Panel members on the draft Panel report, and we've got a bit of work to do to revise it and get the thing into final form. We do plan to issue a final report by June. And as we just discussed, our feeling is that the results of the assessment will be used to help address reactor safety issues as they arise for most applications for high burnup MOX fuel, which we anticipate will be used for severance and risk assessment and other applications, such as the ongoing vulnerability assessment. That concludes my presentation.

MR. SIEBER: It seems to me that when you try to redefine the source term for existing plants, whether it's high burnup or MOX fuel, that the TID-14844 source term was so severe that it would envelope anything you would come up with since, right?

MR. SCHAPEROW: Well, actually, not every aspect. Now, the chemical form, the physical/chemical form, the vapor does tend to envelope things. The timing not necessarily. The timing -- having instantaneous release can cause you to do a lot of things you really shouldn't be doing.

MR. SIEBER: Yes.

MR. SCHAPEROW: And also on the release magnitudes, that was more of a judgment call, the 50 percent iodine release.

MR. KRESS: Actually, the TID-14844 reduced that to 25 percent.

MR. SCHAPEROW: That's correct.

MR. KRESS: So these are actually a little more severe going into containment.

MR. SCHAPEROW: These are 30 and 40 percent for B and a P.

MR. KRESS: But also there's little consideration of gap release in TID-14844 either.

MR. SIEBER: Would this have some generic impact on the things like controlling dose?

MR. KRESS: Yes. In general, the new source terms are a little less severe in terms of things you have to do in dose in the TID-14844. So you're right.

MR. SIEBER: Okay.

VICE CHAIRMAN BONACA: I think for the purpose of the report, which is the one addressing burnup, I think it's very complete. Again, my only suggestion would be although you don't want to address 1465 but to state very clearly that what you wrote in that Slide Number 10, that a number of those lessons learned are not independent, because that message then will be taken once the report is issued, and it will have to be evaluated, I think, to see if changes to 1465 should be implemented.

MR. KRESS: Yes. I think the Tellurium in particular is significant, because it has -- there's a lot of it in there, and it has high biological effect.

VICE CHAIRMAN BONACA: And it goes to iodine.

MR. KRESS: Yes, it goes to iodine. And it may go to it in a way that makes it vapor instead aerosol.

VICE CHAIRMAN BONACA: Okay. Any additional questions for Mr. Schaperow? You're not expecting a report from the CRS at this stage.

MR. SCHAPEROW: No. This is only for the Committee's information.

VICE CHAIRMAN BONACA: Okay.

MR. SCHAPEROW: Only for your information. We'll let you know of some of the fine research people we have going on in the Research Office.

VICE CHAIRMAN BONACA: All right. If there are no additional questions, then thank you very much for the presentation, and the meeting is recessed. We'll reconvene at ten minutes of one.

(Whereupon, the foregoing matter went off the record at 11:50 a.m. and went back on the record at 12:50 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

12:50 p.m.

VICE CHAIRMAN BONACA: Back to order. This is going to be a presentation on high burnup fuel research and regulatory issues. Dr. Kress?

MR. KRESS: Thank you. I don't have a lot of introductory remarks. The Committee might recall that there was an exchange of letters to the places that high burnup fuel research. Probably not needed and we wrote a letter asking for some clarification for that position, and I think this is a briefing to tell us what's been going on in that area and to fill us in. And I guess with that, I'll turn it over to one of the two Ralph's.

MR. CARUSO: This is Ralph Caruso. I'm going to start the briefing this afternoon, and Dr. Meyer is going to finish it. I'd like to open my presentation by, first of all, acknowledging that the letter that we sent -- it was sent from Sam Collins to Donnie back in January of this year. It included some wording that we do consider to be unfortunate. The use of the word, "irrelevant," was probably not advisable. The Office of Nuclear Reactor Regulation does consider that the work that's done by research is valuable, and we do support it.

Notwithstanding that observation, there are different types of research that are done in the Office of Research. There is research that is requested by the various offices, there is confirmatory research, there is anticipatory research, and we're here today to talk to you about one aspect of the high burnup fuel research program. Actually, I'm going to give you a little bit of an overview, some background on high burnup fuel. Dr. Meyer is going to talk to you about the program itself. I'm going to give you a little bit of history, and I'm going to talk about the 280 calorie per gram limit and where we stand on that particular aspect of that in regulatory space.

MR. POWERS: How about the 180 calorie gram per limit?

MR. CARUSO: I get into that as part of this -- 170.

MR. POWERS: Hundred and seventy.

MR. CARUSO: I'd like to start with the first slide, which is background about -- an NRC user need request was sent to the Office of Research in 1993. At this time, the Agency was receiving a number of requests from the vendors to increase burnup limits, to go from numbers that were in the 30s and the 40s at that time, up to about 60 or 62. And NRR at that time decided to send a user need request to Research to update a number of different regulatory tools.

One of them was the NRC fuel performance models. These are included in various computer codes that are used by the Agency to perform independent calculations of fuel behavior. In addition, there was a request to revise some models for stored energy during LOCAS and evaluate the impact of these models on LOCA analyses.

We also requested research to reevaluate some of the fuel failure thresholds that are used for normal operations and RIAs. This is the 280 calorie per gram limit and the associated 170 calorie per gram limit that I'm going to talk about later on.

Nineteen ninety-six, after a bit of work had been done by the Office of Research, a Commission memorandum was sent that talked about some low enthalpy fuel failures that occurred in some research reactors. And it talked about a new complete rod insertion issue that was becoming evident in a number of operating plants.

In 1997, we sent another Commission memorandum talking more about the regulatory guidelines and licensing criteria for high burnup fuel, talking about high enrichment, because at that time there was some evidence that some licensees and vendors might want to go to high enrichment. And we were also talking about spent fuel issues, because the higher burnup fuel is causing some difficulties with storage and transportation.

In 1997, Research issued a research information letter. This RIL, as it's called, proposed some changes to the RAA criteria that were used -- that were, and still are, contained in Reg Guide 1.77 and in the Standard Review Plan, Section 4.2. The RIL discussed the history of some tests at some test facilities -- CABRI and NSRR. And discussed how the criteria could be changed in order to accommodate this data.

Eventually, the Agency put together a program plan in 1998 that included these revised interim proposed limits, and laid out a larger program for the Office of Research to perform confirmatory research to verify and validate a number of fuel performance models, computer codes and fuel performance data. It also looked at transportation, dry storage, source term, whole bunch of issues.

This program plan made it clear that the body of the plan that the NRC Research would be done to confirm material properties and fuel behavior for burnups up to 62 gigawatt days per metric ton. The body of the report -- the body of the memorandum stressed that it would be the industry responsibility to develop the criteria -- I'm sorry, excuse me. For the criteria that they don't -- and the models for burnup higher than 63 --

MR. WALLIS: Excuse me, Ralph. What was actually the burnup which was being achieved in reactors at that time?

MR. CARUSO: Let's see, in 1998, we had already licensed at that point most of the fuel to 62.

MR. WALLIS: And then you were doing confirmatory research to check that --

MR. CARUSO: Yes.

MR. WALLIS: -- you'd done the right thing.

MR. CARUSO: That was the intent of the Agency high burnup plan at that time, to do confirmatory research to verify that. The decisions that have been made were valid. The attachment to this Agency burnup plan also included some statements about how research might cooperate with the industry in doing the testing and gathering some data for burnups above 62.

MR. WALLIS: Just remind me, when you say gigawatt days per metric ton or uranium? That means all of the uranium?

MR. CARUSO: Okay. This is the value that's used, and this is -- you have to be careful about how you use it. This is a peak rod average value.

MR. WALLIS: This is for all the uranium?

MR. CARUSO: For the peak rod average burnup shall not exceed 62 gigawatt days per metric ton. If you look at each rod and you look at the peak rod average, you take the burnup over the entire rod and you average it so that you have an average number for the rod.

MR. WALLIS: Yes.

MR. CARUSO: The peak rod in any core should not exceed 62 gigawatt days per metric ton.

MR. WALLIS: That's Uranium 238 is mostly what --

MR. CARUSO: Metric ton -- MTU, metric ton of heavy metal.

MR. WALLIS: So when you change -- there's nothing here which says what's the effect of changing in Richmond or more plutonium or anything like that at all.

MR. CARUSO: No, no, no.

MR. POWERS: How was 62 selected.

MR. CARUSO: Sixty-two -- you're going to ask me why. This is getting back into history before my time, so I'd have to reconstruct it. I don't honestly know, because I wasn't involved in the cutoff. It's my understanding that the industry tried to push beyond 62, and the Agency said, "No. This is as far as we're willing to extrapolate the data at this point." And a conscious decision was made sometime in the '90s to stop at 62 until data was available.

The RAI regulatory criteria. They come from GDC. Their origins are in GDC 28, and I've quoted it here. As you see, the criteria are pretty general GDC 28. They're not allowed to have a reactivity increase that would result in damage to the reactor coolant boundary greater than limited local yielding or sufficiently disturb the core at supporting structures or other reactor coolant pressure vessel internals to impair significantly the capability to cool the core. That's the mother document for determining RAI criteria.

MR. WALLIS: What does limited local

yielding mean?

MR. CARUSO: That's the question of that ages. That's difficult to determine. So as a result, there are couple of surrogate acceptance criteria that are used. We have a Standard Review Plan, Section 4.2, that talks about coolable geometry. I want to get this first. It defines coolable geometry as, "Retaining a rod bundle geometry with adequate coolant channels to permit removal of decay heat." That addresses the second part of GDC 28.

The first part of GDC 28 is addressed by limiting the fragmentation and dispersal of molten fuel from inside the cladding into the reactor coolant system. And because it's very difficult to calculate the damage to the reactor coolant pressure boundary limited to local yielding, we use this surrogate of making sure that you do not have a violent core coolant interaction event. And the way we do that, the way that it has been done in the past is by limiting the average radial enthalpy limit of 280 calories per gram during an RIA. The calculation is done by the vendors of a hypothetical RIA, and it's almost always a rod ejection accident. And they verify that the average enthalpy does not exceed this 280 calorie per gram limit.

And this 280 calorie per gram limit was based on some experiments that were done in the SPIRT facility back in the '60s, '70s, where they observed that if you got enthalpies up in the 300, 325, 350 range, you got a very violent expulsion of molten fuel and you got a very strong pressure pulse, and it was thought that 280 calories per gram would provide enough margin so that we didn't have to worry about that.

MR. KRESS: Those expert tests were done with what burnup?

MR. CARUSO: They were done with pressure or low burnup. We did a relatively low burnup fuel.

MR. WALLIS: Doesn't this depend on the fuel design? Haven't fuels changed since that time?

MR. CARUSO: The fuels have changed, but they're still basically uranium oxide. And the concern that really arose was molten fuel. You're talking about does the uranium oxide melt, and do you have an interaction, a steam explosion of molten UO2 and water? So although the fuel designs have changed, the fundamental phenomenon really is the same. You're trying to prevent a steam explosion, and the thinking is that if you prevent a steam explosion, therefore you won't have to calculate the pressure pulse, and therefore you won't have to calculate the building of the reactor coolant pressure boundary.

MR. KRESS: And the 280 calories per gram was sufficient -- insufficient to raise the temperature to melt a certain fuel?

MR. CARUSO: To melt it, right. That's what was thought at the time. Since then it appears that the melting enthalpy may be somewhere around 260? So this number may not be demonstrably not conservative anymore.

MR. WALLIS: There's nothing here about burnup.

MR. CARUSO: That's correct.

MR. WALLIS: And, presumably, with a lot of burnup the fuel is more likely to --

MR. CARUSO: I'll get to that. Well, we'll talk about that.

So with that as a background, we look at what came out of the CABRI and NSRR tests. The CABRI and NSRR tests showed that fuel could fail at much lower energies than 280 calories per gram. The SRP actually contains a secondary failure criteria of 170 calories per gram. The 170 calorie per gram number is used to determine when dose calculations need to be done. There's a two-step regulatory process here.

The licensee is required to assure that the fuel will not melt and be released into the reactor coolant system. That's what the 280 calorie per gram number is.

And then if they calculate that some of the fuel exceeds 170 calories per gram, they're required to calculate for those pins which exceed the 170 calorie per gram limit what the dose would be, the release from the fuel of the fission products and then the release through the reactor coolant system and out through any holes in the reactor coolant system and out through the containment to members of the public. And the standard for that is that that release should not exceed a small fraction of the 10 CFR Part 100 limits. That's what the 170 calorie per gram limit is. It's a no-fuel failure limit, but it's not actually a limit, it's just a point at which you decide to do a dose calculation, not a limit per se.

Now, we had this experience at CABRI and NSRR where the fuel failed at low enthalpies. There are problems with those tests, though. The NSRR tests were done at room temperature, low pressure. The CABRI tests were done in sodium. You can make scaling arguments, but there were problems with the amount of corrosion on some of the rods. In some of the tests, there were --

MR. POWERS: Can you tell what you mean by problems?

MR. CARUSO: Well, some of the rods that failed had much higher levels of corrosion than we really expect to see inside an operating PWR. There were some rods that had spalled fuel.

MR. POWERS: But these rods came from operating reactors.

MR. CARUSO: They might have come from operating reactors, but they also might have been preconditioned. There were questions about them. That's not really important at this point, okay, because we know they --

MR. POWERS: But it's important enough to put on the viewgraph.

MR. CARUSO: Well, I wanted to make it clear that there were atypicalities about these tests.

MR. POWERS: I guess I'm struggling to understand what's atypical.

MR. CARUSO: Well, had to do, for one thing, the corrosion, the fact that they were in -- the tests were done in sodium or at low temperatures.

MR. WALLIS: Well, the obvious question now is --

MR. ELTAWILA: Dana, this is Farouk Eltawila from Research. I think the issue, and Ralph can correct me, is that the oxidation and spoilation it might be typical of what you have in nuclear power plant, but during the conditioning of the specimen for the test, they oriented all the hydride in the same direction. So with that small pulse, it will fail. And this preconditioning does what's typical, which is not defeat itself.

MR. MEYER: Could I clarify this? The concern about preconditioning, and you can call it fabrication of the specimen from a fuel rod and preconditioning, the concern has only been expressed about one test rod, the one indicated up there from CABRI, Rep NA1.

MR. POWERS: Well, let me express a concern about all the others.

MR. MEYER: Okay.

MR. POWERS: You have a fuel rod that you've selected in some way to extract a specimen from, and all these tests are done with not full fuel rods but some sections, so somebody has to cut it out. When you send that to a lab operator and say, "Cut me out a section or a particular length," that section is not randomly selected; in fact, the operator operates considerably on his own to do that. Would an operator in a hot cell facility with production quotas on him select a section of the rod that is as pristine as possible to enhance his chances of getting a successful cut?

MR. CARUSO: Yes. Of course that could be done, but that's not what is done. In fact, what we have found is that for the PWR fuel that there's a fairly monotonic increase in the corrosion from the bottom to the top, and the grid span next to the top has, if not the highest level of corrosion, almost the highest level of corrosion, and it also has a uniform burnup over that span. And we typically will select that span because it represents the worst condition in the rod.

We have in three cases tested an upper grid span and a mid grid span with considerably less corrosion and done comparative tests three different times, once in CABRI and twice in NSRR. And in those three cases -- in all three cases, the rods from the upper grid span experienced cladding failure, and the ones from the lower grid span did not. So this is a way that we can study the dependence of this on the oxide quantity.

MR. WALLIS: Then the real question for me is you have some tests in SPIRT, you have some of these tests, some of which you seem to cast doubt upon from CABRI and NSRR. What is the status of knowledge based on factual information from tests, the tests achieved here?

MR. CARUSO: Well, the distillation of the knowledge from those tests came out in RIL 174. At that time, the RIL 174 made a recommendation to change the acceptance criteria for RIAs that were in Reg Guide 1.77 and in the Standard Review Plan, as described on this page here. Oxide spalling would not be allowed. Spallation was not good because it creates weak spots in the fuel. Cladding failure limit, the 170 calorie per gram limit, would drop to 100 calories per gram. And the coolability limit would change from -- well, right now it's at 280 calories per gram with no burnup limit. It would change to be 280 calories per gram for burnups less than 30,000 megawatt days per metric ton or for burnups greater than 30 gigawatt days per metric ton, the criteria would be no cladding failure, i.e. 100 calories per gram. Also, is it the RIL or the -- I'm not sure if it was the RIL or the Agency program plan which noted that the 280 calories per gram number might be reduced to 230 because of the evidence --

MR. WALLIS: I guess you're describing a regulatory action. I don't know what this 100 calories per gram is based on. It may be based on the fact that you had a very poor basis for decisionmaking, so you did something very conservative. Or it may be based on tremendously good experimental basis, which may have drove you to a 100 calories per gram.

MR. CARUSO: Ralph has the paintbrush slide here, which is -- we call it the paintbrush slide.

MR. WALLIS: My impression is there's a very small test basis for this decision.

MR. MEYER: There is a fairly small database, and unfortunately when I grabbed this slide, I didn't get the latest version of it, so there are some missing points.

MR. ROSEN: Slide it over a bit so we can see the --

MR. WALLIS: At least there's a scale on the y-axis.

MR. ROSEN: That's right.

MR. MEYER: Yes, there's a scale on the axis.

MR. ROSEN: It should have a scale on the right.

MR. CARUSO: The numbers in the circles correspond to tables in a publication. And it's a paper that we wrote. And the indicators outside of circles correspond to tests that have been done since that paper was published. And there are some data that are not on here. I know this will be unsatisfying to people who collect good data. It is all we have to go on, and so we resort to drawing our lines with broad brushes. We have a better understanding now than we had in 1977. I can tell you something about the personality of each of these data points and the pulse with the test temperature and other things that we believe would make the points either move up or down if you were able to normalize this to a set of appropriate conditions.

The bottom line is once you get away from uneradiated material, a new damage mechanism comes in, and it is a mechanical interaction from the expansion of the pellet pushing against the cladding which has lost some of its ductility. And we plot this typically -- we do, not everybody in the world does -- but we plot it as a function of corrosion in some measure here, the oxide thickness, because it appears that the oxidation on the rod gives a stronger dependence than the actual burnup.

MR. POWERS: Well, if we move to clads that are less corroded --

MR. MEYER: Yes.

MR. POWERS: -- in the reactor, but they still harden in the course of irradiation, what do you change that outside thickness to?

MR. MEYER: The irradiation hardening, we've always thought that the irradiation hardening hits a stable point very early, about ten gigawatt days per ton, and you get some equilibrium where you're annealing it as fast as you're putting it in. And it doesn't seem to be as important as the embrittlement that comes principally from the hydrogen that's absorbed when you oxidize the cladding and steam. So it's really -- there are two major variables, burnup and -- or you could say fluency and oxidation. We have simplified for this plot and may simplify it in application, because I don't think we're going to be able to resolve the dependence on the set of variables.

MR. KRESS: If I look at that curve, Ralph, and look at things above 40 on the oxide thickness--

MR. MEYER: Yes.

MR. KRESS: -- it looks like in order to envelope those black dots, you need a much lower value.

MR. WALLIS: Everything fails pretty much.

MR. MEYER: That's right. And, unfortunately, the points that have not been put on this add two more right down there in that cluster.

MR. KRESS: Black dots.

MR. MEYER: Black dots. Now, here's where you have to start looking at the test conditions, because those are all tests in NSRR. They're tests at room temperature, and the accident of interest is a hot zero power accident. That's the worst one, the one we look at. And so the temperature should be almost 300 degrees centigrade, 285, 300 degrees.

MR. KRESS: Which makes the clad more ductile.

MR. MEYER: Which makes the clad more ductile. In addition to that, there are different pulse widths between these facilities. The JAERI facility has a very narrow pulse of about four and a half milliseconds, and the CABRI has a normal pulse of about nine and a half milliseconds, but they have artificially broadened it to as high as 80 milliseconds in some tests. And this affects the temperature of the cladding during this rapid period, the temperature of the cladding at the time that the stress is applied.

MR. KRESS: It doesn't have time to get the heat from inside to the clad.

MR. MEYER: Right. So if you imagine adjustments to all of those, you take the JAERI points and you push them up. And so we intentionally drew our line above some of the points from NSRR.

MR. ROSEN: This pulse was compared to what in the real case? Between four and a half and nine is what your test facilities have shown. In the real case, what should they be if we were actually trying to --

MR. MEYER: That's a very interesting question, because for years we all thought that typical pulse widths that an LWR would produce in an accident like this was 30 to 50 milliseconds, and in fact last summer I asked Brookhaven, who had done an extensive study on calculations, to go back and plot this out as a function -- pulse width as a function of the energy and the pulse.

And for pulses in the neighborhood of cladding failure, that is anywhere close to 100 calories per gram, 60 to 100 calories per gram, LWR pulses will be about ten milliseconds. And we mistakenly thought they were much larger than that. So at the time we drew this figure, we're thinking that the JAERI pulses are far too narrow and that the normal CABRI pulses are too narrow and the broadened CABRI pulses are the right ones.

MR. CARUSO: There's some question about whether PWRs can actually get those sort of pulses, though.

MR. MEYER: Well, let me respond to that by saying we all believe, all of us who are involved ion assessing this, believe that at the end of the day when we get the fuel damage criteria that we're looking for, whatever it happens to be, that when a plant accident analysis is done for real core designs and real conditions, that you won't get there.

MR. KRESS: Is rod ejection --

MR. MEYER: Rod ejection --

MR. ROSEN: You won't get where?

MR. MEYER: You won't get up around 100. You'll get maybe 30, 40 calories per gram max.

MR. ROSEN: What about the pulse width? What would the pulse width be in real plants?

MR. MEYER: This is for a real plant, and this is several sources of data, and the difference between them if fairly minor. So if you have a 40 calorie per gram pulse, this is in fuel enthalpy increase. This is not actual energy of the pulse. There's a small difference because of heat conduction. At 40 calories per gram, the pulse width is roughly 20 milliseconds.

MR. ROSEN: You're not answering my question. With all due respect, Ralph, I don't think you're answering my question.

MR. MEYER: Okay.

MR. ROSEN: It is not about experimentally what the pulse width is that produces a maximum delta H that you've shown here, but when a plant has, for example, if the plant had a rod ejection accident, how wide would the pulse be?

MR. MEYER: That's what this is. This is a plant calculation. This is not a test result or a test calculation.

MR. ROSEN: So how do I pick the pulse width? Is it 100 or is it zero?

MR. MEYER: It depends on how much reactivity is in the rod that gets ejected.

MR. KRESS: And where the rod is.

MR. MEYER: Yes.

MR. CARUSO: Whether the rod is inserted

or whether it's normally all the way out?

MR. MEYER: I can tell you that it would take a reactivity of about $2 to get 100 calorie per gram pulse.

MR. KRESS: That means the rod's all the way in and it's a really effective rod?

MR. MEYER: I don't have a good feeling for it, but I'm told that's too big. That's a big number.

MR. KRESS: That's a big rod.

MR. MEYER: And you're not going to find any $2 Rod Worths.

MR. KRESS: Most of them are around 50 cents, I think.

MR. MEYER: Most of them are?

MR. KRESS: Around 50 cents or something like that.

MR. CARUSO: The rods tend to be much lower than the values that are assumed in the accident analysis.

MR. MEYER: But I think that's -- this is the nature of the exercise. You find out where the damage limit is that you can tolerate, and then you do the plant calculation and hopefully show that you don't get to that damage limit. So we don't expect the plants to be able to deposit the energy in the vicinity of where we're doing the test, because we're trying to do the test to find out what the limit of damage is that we want to tolerate.

MR. KRESS: But the point is that when a plant makes a calculation for its design, it's going to calculate a number.

MR. MEYER: Yes.

MR. KRESS: And you're going to say, "We want that number to be less than 280 or less than 100," right?

MR. CARUSO: Well, actually the way the vendors do it -- until now the vendors have all been using 1-D methodologies. And this issue came up in the mid-'90s. They were asked if they had any better estimates of the actual values, because they were using conservative 1-D methods. Using 3-D methods, they estimated that the numbers would be well below 100. And we have this information from all of the vendors, and this is something that Brookhaven has also calculated. For real cores using 3-D methods, the values will be much lower than 100.

And about a month ago, we received a topical report from I can say Westinghouse to review so that they could redo their calculations using a 3-D methodology. And this is a comparison of two fuel enthalpy calculations that they did, one using a 3-D methodology and one using a 1-D methodology for the limiting pin. And you can see -- you have to use the scale on the right, not the BTUs per pound, calories per gram.

And you can see that for this limiting fuel rod, the values are well under 100. They're in the neighborhood of about 70. This would be for a rod, I believe, early in life, maybe at the end of the first cycle, sometime in the first cycle, early in the second cycle. This is typical of the results we see from the vendors when they use more realistic but still conservative analyses.

MR. KRESS: So you're saying you've got lots of margin to this 100.

MR. CARUSO: Lots of margin.

MR. KRESS: But --

MR. CARUSO: I'm getting way ahead of myself.

MR. KRESS: Yes, but the point is if somebody were to come in with a calculation that says it was 99, you'd still would have used up all your margin, but you would approve it. You'd still meet your regulatory criteria.

MR. CARUSO: We haven't set these new regulatory criteria yet.

MR. KRESS: Well, whatever the criteria is.

MR. CARUSO: And that's something that we do have to do.

MR. KRESS: Yes.

MR. CARUSO: And we're waiting for the results of the work that Research is doing to revise Reg Guide 177 and the SRPs. When that work comes in, we will revise those regulatory criteria. In the interim, though, we have lots of licensing actions that need to be done. This morning I talked to you about power uprates, I've talked about PWR power uprates. Work continues. So I can't --

MR. KRESS: I heard you say you're waiting for the results of the research. Does that mean the operative words in the previous slide are no longer operative?

MR. CARUSO: No. It says that we will use the results of the research work. I mean I can't ignore it, I shouldn't ignore it. I will use it. I will use it to revise the regulatory guidance. But until that's done I still have regulatory activities that I must continue to do. I can't just stop and wait.

MR. WALLIS: Well, you can. I want to go back to my first question. You have not -- I think you've convinced me that you do not have a good basis of test data on which to base these decisions. You've got points which are all over the place. You don't have a very good understanding of how fuel fails, and this 100 calories per gram has been obtained by some very broad brush estimate.

MR. CARUSO: Well, the 100 calorie per gram number is the number we were going to use for fuel failures. Remember that the GDC criteria is two parts. GDC criteria is no threat to the reactor coolant pressure boundary and no loss of coolable geometry.

MR. WALLIS: I don't really care what you're going to do regulatory-wise. You haven't convinced me you have a good basis of knowledge on which to base your decision.

MR. CARUSO: Oh, but you see I have to make the decision about whether I will meet the general design criteria. The general design criteria is the ultimate acceptance criteria, because as a regulator that's my criteria.

MR. WALLIS: How can you do it if you

don't have a good basis of knowledge?

MR. CARUSO: Well, I do as good a job as I can with the information that's available to me.

MR. WALLIS: Then you must have tremendous uncertainty in your decisionmaking.

MR. CARUSO: And we do. We do have some uncertainty, but I'm about to get into the reasons why I sleep well at night, even given that degree of uncertainty.

VICE CHAIRMAN BONACA: One thing that you said, it sounds almost as if there is new information coming because for the first time they're doing 3-D methods. That's not true. I mean I can remember that combustion engineering was using a 3-D model method seems for years, 25 years ago, Hermit, I believe, is the name of it. I think it was a credible nodal method. I don't know what this is. I don't know, for example, what kind of work you're ejecting here. I see that this is a protracted transient and typically we have seen them turning faster now. I'm trying to say that they've been using -- yes, Westinghouse has been using some kind of synthesized method, they were using 1-D and 2-D and tied them together, and they were not really a 3-D. And so I'm trying to understand what we've learned in the past ten years that is so different from what we learned before.

MR. CARUSO: Well, what we've learned from the research program is that the fuel failure limit is not correct. It shouldn't be 170 calories per gram, and the 280 calorie per gram limit needs to be revised also.

VICE CHAIRMAN BONACA: No, I was asking about the results that the vendors are showing now. Why are they so lower?

MR. CARUSO: Now, what the vendors are doing, and this is going to get ahead of myself here again, the vendors are preparing for what's called extended burnup fuel above 62. And for burnups above 62 we've said they've got to provide the criteria, they've got to provide the data, they've got to show why it's safe. We're not going to do that. They've go to do that work. Now, they have, just last Thursday, sent in a topical report on this subject which proposes changing the limits. And they've proposed changing the limits to about 230 calories per gram for the upper limit and about -- still leaving it 170 for burnups below about 35 gigawatt days per metric ton, dropping to about 130 calories per gram at about 80,000.

MR. KRESS: Is this based on new data?

MR. CARUSO: They don't have any more data than Ralph has.

MR. KRESS: Okay. So it's --

MR. WALLIS: How can they possibly justify it, except by arm waving and theory?

MR. CARUSO: That's a good question. We just got this report Thursday, and we have to review it.

MR. ROSEN: I think it would be appropriate to read it.

MR. CARUSO: Pardon?

MR. ROSEN: I said it would be appropriate to read it.

MR. CARUSO: Exactly. But if you -- you were asking the question what's going on and why am I getting this all of a sudden if the vendors already have these methods. They want to go to higher burnup, so they have to have better methods to go to the higher burnup. So Westinghouse has got the jump on the other two vendors by submitting a method here.

VICE CHAIRMAN BONACA: I just was taking exception on their statement that until recently they used 1-D methods and they didn't.

MR. CARUSO: What I mean by use it is in the regulatory context, in terms of the approved licensing methodologies, they've been using 1-D methods.

VICE CHAIRMAN BONACA: Westinghouse has used, not -- so, anyway.

MR. CARUSO: Okay. Let's see, where was I? I think we got sidetracked.

MR. POWERS: Let me continue the sidetracking a little bit.

MR. CARUSO: I'll put this one up.

MR. POWERS: What I'm struggling with a little bit, Ralph Meyer, is you and your colleague have critiqued what data you have based on the experimental technique that was used. And your critiques sound possible to me. The experiments are not high-temperature experiments and what not. And so you've thought, "Well, maybe I should move my criteria in just a little bit to reflect what I think the fuel would do if I had done the experiment correctly, I mean an absolutely prototypic experiment." And it sounds as though you've gotten a topical report that comes in and says, "Okay, we can move these lines a little more because we think this fuel will behave even more differently if the experiment had been absolutely prototypic."

Is there, within the psyche of the Agency, any plausible argument of moving those lines around where you set the criteria that could be accepted without at least one experimental data point to show that what you think the fuel would do had the experiment been prototypically done it would in fact do?

MR. MEYER: Yes. In fact, since the 1997 information letter, we have not made any further statement about how we think that -- about where we think that line should be drawn. We have learned enough from recent tests and from our kinetics analysis to hone in on what we think are fairly definitive parameters. And the one thing that we are waiting for in order to make another estimate is a set of tests that are now scheduled for 2004 in the NSRR test reactor in a new high-temperature, high-pressure capsule. So NSRR at that time is going to make a direct comparison between the room temperature test and a test conducted at the right temperature.

Now, they will not be able to vary the pulse width. The pulse width will still be about five milliseconds, and at the energies of the test the correct pulse width should be about twice that. Now, we do have varying pulse widths from CABRI.

MR. POWERS: Could I just hone in a little bit on this issue of pulse width? And just tell me if my understanding of the pulse width issue is correct. The issue is one of how much heat do you get into the clad, as opposed to keeping it all in the fuel? And there must surely be a pulse width that is so narrow that no heat goes into the clad at all. And any pulse width really doesn't change phenomenology; is that correct?

MR. MEYER: Yes.

MR. POWERS: And the question is can you give us an idea of what that pulse width is such that essentially no heat goes into the clad?

MR. MEYER: Yes. More or less, it's around 20 milliseconds.

MR. POWERS: So it really doesn't matter whether they have a five or not.

MR. MEYER: My opinion at the moment is that I doubt it.

MR. POWERS: Okay.

MR. KRESS: And not only that, the narrower the pulse width, the more conservative the result is with respect to --

MR. MEYER: Certainly. You could say that. There is another -- there are two effects that are hypothesized. One of them is the temperature effect, which we've spoken of, and it obviously exists. How important it is we don't quite know yet. Because in fact when you start looking at the mechanical properties measured separately as a function of temperature, in the range from room temperature to 300 degrees centigrade, uniform elongation for Zircaloy and some other alloys doesn't show a temperature dependence there. But the total elongation that's been measured shows some. But total elongation is a funny property. It's not really a materials property. It depends highly on the test arrangement. So I don't know what to expect -- something or nothing.

There is another effect that's hypothesized, and that has to do with a dynamic gas -- fission gas expansion that might increase the loading. In the picture here -- I don't have a slide to illustrate this -- but the picture here is grain boundaries, ten micron size, roughly, which are decorated with fission gas bubbles under high pressure, lots of them and they're small, and a rapid temperature transient that expands those bubbles, forcing the grains apart and sort of acting like levers to add to the mechanical loading on the cladding from the thermal expansion of the O2 itself.

Now, I don't know whether that's a real effect, an imagined effect, how important it is.

MR. WALLIS: This is just part of it. I mean my colleague is talking about a relaxation time for the fuel to share energy with the cladding, which we're talking about on order of ten milliseconds. There are all kinds of non-homogeneities in this fuel. There are spots where there's more fuel than others. It's not absolutely uniform. So at some microscopic level, when you zap it very quickly, there are certain spots that get hotter than others. There's all kinds of things that happen microscopically in there.

MR. MEYER: That's correct.

MR. KRESS: You get more in the power going into the --

MR. WALLIS: The little nodules of plutonium or whatever is in there in the MOX fuel.

MR. MEYER: In high burnup UO2 fuel, I think it's pretty homogeneous. The thing that -- where we are on the lookout for such an effect is in the MOX fuel, which is not -- it's fabricated with inhomogeneities which may never disappear. And so that's a separate matter. I mean it's real. We have a few tests on MOX fuel, and that's a real effect. The dynamic gas expansion, I don't know if it's real or not real, but it's possible.

MR. POWERS: I'll just sideline us just a little more because he provokes me all the time with these wonderful statements, things like that. Ralph, you said that you thought in a high burnup fuel the power input was fairly uniform?

MR. MEYER: That's what I said. Is that wrong?

MR. POWERS: It seems to me that I have seen plots that would suggest to the contrary, that it's highly peaked around the periphery.

MR. MEYER: Oh, oh, okay. Sure. I thought you were talking about like little local islands of inhomogeneous stuff.

MR. POWERS: Oh. Okay. What you're saying is --

MR. MEYER: It's creamy smooth, but it's got a heck of heat on the end.

MR. POWERS: On the perimeter.

MR. MEYER: Oh, yes.

MR. POWERS: But certainly uniformly across the pellet there.

MR. MEYER: Yes.

MR. POWERS: Okay. I understand now. I'm sorry.

MR. RANSOM: I have a question. Why is the 3-D and 1-D so much different? In fact, it seems counterintuitive, I would think, that the 3-D might reveal a higher new energy locally per gram than say a 1-D energy.

MR. MEYER: I can't answer that question. Maybe somebody --

VICE CHAIRMAN BONACA: The 1-D were never neutronics, they were just point kinetics --

MR. RANSOM: Right. But that's the entire core they're doing 1-D, right?

VICE CHAIRMAN BONACA: That's right. But I'm saying --

MR. RANSOM: Versus a 1-D where you've actually getting variations across the cross section.

VICE CHAIRMAN BONACA: Yes. But they were using typically static calculations. And so it didn't have all the effect of feedback that you will get in a neutronic calculation of 3-D.

MR. RANSOM: Is that the explanation that the feedback is much different then?

VICE CHAIRMAN BONACA: That was a key difference there.

MR. CARUSO: Let me go on to my next slide, which is what I call "why I sleep well at night" slide. When this issue arose from the CABRI and NSRR tests, we talked to the vendors and they performed some 1-D calculations or they showed us some 1-D calculations that showed that the neutronics would be much better. The limiting fuel, the graph I showed you for the Westinghouse plot, this is for fuel that's less than 30 gigawatt days per metric ton for which we think the 280 or even the 230 value is still reasonably a good value to use.

MR. POWERS: Why do you think that?

MR. CARUSO: Well, we -- I'd have to go back to the paintbrush plot, and if you look at the paintbrush plot and look at burnup against failure, you plot burnup against failure, you'll see that this fuel at less than 30 gigawatt days per metric ton doesn't fail.

MR. POWERS: I think that I will not see that. If we could put the paintbrush slide up, I will be stunned to see --

MR. CARUSO: It's not as a function of burnup. It's a function --

MR. POWERS: No, I understand that, but we can -- I'll be willing to make a mental change and point to a bunch of plots at around 150 and zero and say, gee, those look black to me.

MR. CARUSO: Do you know what those data points are, Ralph?

MR. MEYER: Yes. There were cladding failures in some PBF tests. Where's Harold? Help me -- and the other SPIRT ones? Those were around five -- Harold Scott is the Harold that I'm referring to here, and Harold will come to a microphone and help me recall some of the details.

MR. POWERS: Well, understand the question that's being posed is why anyone would think a 280 or a 230 calorie criterion is adequate for any fuel ever?

MR. CARUSO: First of all, remember that that criteria is not for fuel failure. That's a criteria for ejection of molten material.

MR. POWERS: I will repeat my question: Why would anyone think that a 230 or 280 criterion is appropriate for any fuel ever?

MR. MEYER: Okay. Let me tackle that. If you look SPIRT and PBF data with burnups of less than five gigawatt days per ton, so essentially zero, essentially zero burnup, fresh fuel, some of them had very small amounts of burnup. And there's a fairly sizable database. And you line these up as a function of the peak fuel enthalpy. You'll find a dividing line around 230 calories per gram, where below 230 calories per gram you get no fuel dispersal, and above 230 calories per gram you get fuel dispersal. As soon as you get some burnup, some significant burnup, and the first time this shows up is with a PBF test with a burnup of about five or six gigawatt days per ton, you begin to see the PCI mechanism and the failure at the much lower energies.

MR. POWERS: Okay.

MR. MEYER: It's much below 30.

MR. POWERS: I'm not sure I want to argue with you too much about this, but if indeed seven is your SPIRT data, I certainly see a point up there at zero that seems to suggest you get failure at below 230. So your dividing line is a peculiar dividing line.

MR. MEYER: This is zero on an oxide scale, not a burnup scale.

MR. WALLIS: But it goes down with more oxide.

MR. POWERS: Well, would you expect the oxide to be different than about zero for zero burnup?

MR. MEYER: No, but I expect --

MR. POWERS: Well, then it's a good point.

MR. MEYER: I expect at zero burnup that you don't have any irradiation targeting.

MR. POWERS: Okay.

MR. MEYER: It saturates somewhere around ten or at some low value. So I do think there is something else that is precluding the failure from limited ductility with very fresh materials. And the failure mechanism there is a high temperature oxidation and embrittlement mechanism, something like you have in --

MR. POWERS: Okay. Let me change my question: Why would anybody accept 280 or 230 as a criterion for any fuel with burnups greater than five to eight gigawatt days per ton?

MR. KRESS: If you had a different plot that says on the x-axis quantity of dispersed molten UO2 versus enthalpy increase --

MR. MEYER: That's the important question.

MR. KRESS: -- then you're saying that plot would -- a line drawn through 230 or something like that would show roughly very little ejected below it, and some above it would be ejected is what you're saying, that the criteria for that is just how much molten fuel gets ejected, not whether the --

MR. CARUSO: It's the molten fuel criteria. The 230 is going to be

MR. KRESS: Not whether the clad fails or not.

MR. CARUSO: Not a clad failure.

MR. MEYER: It's not a clad failure, but the 230 in fact corresponds to, for the fresh materials, to no fuel dispersal. I think there were probably in the whole population of tests there were only a couple of cracks that occurred at a lower energy, and they didn't disperse. They didn't lose any fuel from those.

MR. KRESS: Now, if you start fuel out -- if it's running at hot shutdown, is this the test you're talking about? So the fuel starts out something about five or 600 at hot shutdown?

MR. CARUSO: Five or 600 what?

MR. KRESS: Degrees F.

MR. CARUSO: Hot zero power would be 500 to 560.

MR. KRESS: Okay. And you add to that temperature 230 calories per gram. Does the increase --

MR. MEYER: You know exactly the total -- this is the total. Don't add them.

MR. KRESS: I can't locally put that on a piece of fuel and say whether it takes me to molten or not?

MR. MEYER: Two hundred and sixty-seven calories per gram is the solidest for fresh UO2.

MR. KRESS: It depends on what temperature you start from.

MR. MEYER: What?

MR. KRESS: It depends on what temperature you start from. Or are you just giving me the delta H at the melting point to fully melt it? Is that the delta H you're giving me?

MR. MEYER: No.

MR. KRESS: I've got to heat the fuel first, and then I've got to melt it.

MR. MEYER: Two hundred and sixty-seven gets you up to the solidest, and I think you chemists do it from room temperature, don't you?

MR. KRESS: Generally, but we're starting with 500 -- I'm trying to decide how much -- you're giving me a pulse.

MR. MEYER: Okay.

MR. KRESS: I'm trying to decide how much fuel I've got.

MR. MEYER: At hot conditions, 285, 300 degrees centigrade is about 18 calories per gram.

MR. KRESS: Okay. So I'm going to get molten fuel with these pulses, and I'm going to fail the clad. I'm trying to understand the two curves that I see. I've got a lot of molten fuel, and I've got a failed clad.

MR. MEYER: No, no, no, no, no. Something is not coming across right here.

MR. KRESS: Okay.

MR. MEYER: Because the way the SPIRT data were analyzed and the way the criterion is written, it's a total enthalpy. You don't get to add the 18 to that amount. In later test analysis, we have been taking it out and just looking at the delta, because the two main facilities --

MR. CARUSO: Operate from those temperatures.

MR. MEYER: -- operate at different temperatures.

MR. KRESS: So you're saying the 280 is not a delta, it's an absolute --

MR. MEYER: Right.

MR. KRESS: -- enthalpy.

MR. MEYER: Right. Right.

MR. WALLIS: Well, I guess I've got to drop this, but instead of talking if you'd show us a figure which is infinitely more convincing than this one, I would be very happy.

MR. MEYER: Well, I hope in a couple of years when we get these what I view as key tests from Jerry to be able to show you one that's more convincing than this, I don't think you're going to be happy with it, but I think it's going to be probably the best we're going to be able to do maybe ever, but at least for a long time.

MR. KRESS: The reason I was confused is your y-axis says enthalpy increase. That led me into that line of thinking.

MR. MEYER: Again, this is not the plot as a function of burnup. This is --

MR. KRESS: That's the problem --

MR. MEYER: This doesn't have the 18 calories in this plot. Did I say it wrong before?

MR. KRESS: No, no. I was thinking wrong probably.

MR. MEYER: This plot doesn't have. But as Dana points out, this plot doesn't extrapolate to zero at 230. That comes in at 150. The 230 probably has a very limited range of applicability. I agree with you, Dana.

MR. CARUSO: EPRI seems to think otherwise, but we'll get a chance to look at that. I think this is a matter that we will consider as part of the revisions to the SRP and the Reg Guide, and we will ask for your help and we'll ask for the help from the Office of Research, and we'll ask for comments from the industry in order to set those limits.

MR. KRESS: How far are we from being through?

MR. CARUSO: Let me just get through this, because I want to make these points.

MR. KRESS: Okay. Okay.

MR. POWERS: Tom, just for scheduling purposes, the next speaker will be very brief.

CHAIRMAN APOSTOLAKIS: Have you spoken to him?

MR. POWERS: I've had an in-depth with him.

CHAIRMAN APOSTOLAKIS: Okay.

MR. POWERS: And implored him to curtail his normal exuberance.

MR. MEYER: Is that me, Dana?

MR. POWERS: No.

MR. MEYER: Oh. I thought I was the next speaker.

MR. POWERS: No. The next session.

MR. CARUSO: As I said, this is why I feel comfortable with the plants as they are right now.

(Laughter.)

MR. POWERS: Your tolerance, sir, is admirable.

MR. CARUSO: As I said this morning, someone has to make these decisions. And if this is all you've got, then this is all I've got to make a decision. These are expensive tests. I can't go get a lot of data. I would like to have lots of data, but lots of data costs a lot of money.

MR. KRESS: I don't see anything on here that says the expected frequency of rod ejections is very low.

MR. CARUSO: Well, actually, it's contained in the third big bullet, okay?

MR. KRESS: Okay.

MR. CARUSO: Let me just talk about the second bullet first. The fact that the paintbrush slide, as you noticed, was plotted against corrosion. Corrosion seems to be very important for these fuel failures. We are going to materials -- better materials that don't corrode as much, that don't spall, hopefully don't spall.

But the third bullet is the important bullet, okay, about how the machines actually operate. And it's very important to realize that PWRs are designed these days to operate with all rods out during normal operation. Normally they pull all the rods out and they don't go critical because they have boron in them. Gradually they dilute the boron, go critical and operate for a full cycle with all rods out. Therefore, if you have a rod ejection accident, there would not be any rods to eject, because they're already out. There is no reactivity to add.

MR. WALLIS: As long as they stopped. As long as they didn't go into like containment.

MR. SIEBER: The rods are already out.

MR. CARUSO: They're already out.

MR. WALLIS: They're not in containment.

MR. CARUSO: No. They're out of LOCA. They're out of the core. They're sitting on --

MR. WALLIS: I thought the rod ejection was actually a LOCA event where the rod came out and made a hole.

MR. CARUSO: Well, it doesn't have to be, but that's the way we would think of them these days. In order to --

MR. ROSEN: The point is there's no reactivity addition.

MR. CARUSO: There's no reactivity addition.

MR. ROSEN: The reactivity has already been added. When the PWRs are in all rods out configuration, all the reactivity from the rods have already been added --

MR. CARUSO: Exactly.

MR. ROSEN: -- to the core.

MR. CARUSO: Thank you, Dr. Rosen.

MR. ROSEN: There's none left.

MR. CARUSO: The analyses that have been done are analyses of the hot zero power configuration, okay? Hot, some rods in for some reason, zero power, just barely critical, eject a rod, you get the highest pulse. LWR Rod Worths these days are designed in to be small for a number of reasons -- for safety reasons, for economic reasons. There's all sort of reasons rods are designed to have small Rod Worths. And the concern here is about high burnup fuel. Well, high burnup fuel, by definition, has been burned up. Therefore, it has less reactivity than fresh fuel.

And, also, I would add if you look at the number of rods in a typical core that are anywhere near the 62 gigawatt day per ton limit, it's extremely small, extremely small. Batch discharge averages I think in the BWRs you heard this morning are running about 45,000 to 50,000. That's the batch average, which means that there are some rods that are up around 62, but the average is a 45.

MR. POWERS: I hate to bring up the paintbrush slide again, but I did not see anything on that paintbrush slide that suggested there was something magic about 62 gigawatt days per ton; that, in fact, it was a fairly substantial degradation as soon as you crossed -- certainly crossed 40 microns. That seemed to be very big threshold and that there are no pins that seemed to survive beyond that. But even before that, it seemed to me that it was some degradation.

MR. CARUSO: We are working on this. I think that may be a valuable observation, but realize that 40 microns these days with new cladding materials is actually pretty high corrosion.

MR. POWERS: Well, I also hasten to point out that that oxide thickness was selected as the variable on that plot because it was there, not because it reflects on how the clad is actually the embrittlement of the clad. Now, when you change clads, now you've got to change whatever you're plotting against, which is going to be something like a measure of ductility or a measure in embrittlement or something like that. And that when you look at these new clads, you're going to find that they suffer some degradation in strength as you go up in burnup.

MR. CARUSO: Possibly, that's correct. In any case, there's going to have to be a scaling argument made between the materials. I believe most of these tests were done with Zircaloy. We're using now Zirlo or using M5. BWRs use Zirc-2 which is different than Zirc-4. So a scaling argument will have to be made in any case.

MR. POWERS: I would be more enthusiastic about an experimental argument.

MR. MEYER: The CABRI program is test -- its next two tests will be the Zirlo run and an M5 run.

MR. POWERS: Didn't we -- I mean I see papers in the literature that suggest that M5 has the capability of picking up more hydrogen than what you'd find is usual for the Zircaloy.

MR. CARUSO: I don't know that's the case at the normal operating conditions. We do know of this Russian alloy, E110 that seems to pick up a lot of hydrogen during a high temperature LOCA-type transient, where you're up above the Alpha-Beta phase transformation.

MR. POWERS: I see some -- I've seen at

least one paper concerning the can-do conditions, where M5 seems to be picking up -- and it wasn't ever specimen of M5, but some specimens of M5 seem to pick up like twice as much as hydrogen as is normal, as they oxidized.

MR. CARUSO: Yes. I'm not aware of that.

MR. MEYER: I'm not aware of that either.

MR. POWERS: Maybe I should share that paper with you.

MR. CARUSO: Okay.

MR. MEYER: Okay.

MR. POWERS: I have to find it, but it just came to me. It's a curiosity, because it's not every specimen of M5.

MR. MEYER: I mean we did see -- Framatome presented last year, both here at NRC and in a public forum, ductility measurements, these ring compression tests, for specimens that had been oxidized under LOCA conditions. And, in fact, the hydrogen content in those specimens were surprisingly low.

MR. CARUSO: That's what I thought. I thought they were showing --

MR. MEYER: Yes. Whereas the similar rings of E110, which is the same nominal alloy, sucked up a lot of hydrogen under very similar conditions.

This, by the way, is something that we don't understand fully. We have -- I want to say this. We have the full cooperation from Framatome on this. We have signed an agreement with them to do some cooperative research on M5 cladding at Argon under these conditions to try and understand the situation.

MR. CARUSO: I think that's all I've got to --

MR. WALLIS: Ralph, did you ever mention ATWS? Do you worry about fuel failure during an ATWS event?

MR. CARUSO: Fuel failures during an ATWS --

MR. WALLIS: Calories per gram are used as a criterion for an ATWS --

MR. CARUSO: ATWS criteria -- well, we have a rule for ATWS, and then there are several subsidiary criteria that are used to verify that the rule is still applicable to new fuel designs or changes in power level. And those relate to PCT, containment issues, containment peak vessel pressure. But for fuel it's a peak cladding temperature of 2200.

MR. POWERS: There isn't a calories per gram?

MR. CARUSO: Lately, for certain ATWS

instability events where you have an ATWS and you've had an instability, some calculations have been done because they were not able to show that they met the 2200 degree limit for an unmitigated ATWS event, unmitigated ATWS instability event. So realize the event you're talking about you're having an ATWS --

MR. POWERS: I think when we were listening to these power uprates, they showed us a peak --

MR. CARUSO: Right.

MR. POWERS: -- and they talked about calories per gram.

MR. CARUSO: Right. That's correct. That was because they did not meet the 2200 limit.

MR. POWERS: What sort of calories per gram were we talking about?

MR. CARUSO: Actually, I have a chart here, and I believe the numbers are on the order of 70 or 80 calories per gram.

MR. POWERS: So it is a consideration.

MR. CARUSO: It is a consideration, but, once again, you have to consider what the event is for which this was calculated. This is an unmitigated ATWS instability event.

MR. MEYER: Are those 70 or 80 numbers

recent numbers?

MR. CARUSO: Let's see.

MR. MEYER: Because in NEDO 32047, which was audited by NRR, I understand that the number was 250 and said to be less than 280 and therefore okay.

MR. CARUSO: This is out of any DC33006P. This is actually out of a MELLA topical report. Excuse me, let's see, GE14 --

MR. WALLIS: I just thought that while --

MR. CARUSO: -- 64.

MR. WALLIS: -- you say why you slept well at night, you ought to cover the ATWS thing, that's all. And now you're doing it.

MR. CARUSO: Sixty-four calories per gram, excuse me.

MR. WALLIS: And that's okay.

MR. CARUSO: And that's okay.

MR. WALLIS: By legislative --

MR. ROSEN: Ralph Caruso, on your "sleep at night" slide, under PWR operational practices, something I claim to know something about, this hot zero power case that you say is analyzed, you say that's a reason you sleep at night. Is that because PWRs are not at hot zero power very often?

MR. CARUSO: That's correct.

MR. ROSEN: Probably less than one percent of the time?

MR. CARUSO: Probably much less than one percent.

MR. ROSEN: Probably much less. I'll give you a tenth of one percent of the time, eight hours per year.

MR. CARUSO: Yes.

MR. ROSEN: Plants don't like to stay at a hot zero power.

MR. CARUSO: That's correct.

MR. ROSEN: It's not a place you want to stay. You're either shutting down and going through it or you're going the other way as fast as you can to get to power.

MR. CARUSO: Yes.

MR. ROSEN: Okay. So it's a probability argument. While you're exposed in this position --

MR. CARUSO: I hesitate to make that statement, because I'm not a PRA expert, and I can't defend the --

MR. ROSEN: Well, we did do --

MR. CARUSO: -- probability of that.

MR. ROSEN: Well, I can make the statement, and I think there's hardly anybody in this room that would deny it, except perhaps -- well, I'll just say not very many people -- that plants don't stay at hot zero power very long.

MR. MEYER: Brookhaven did do a probability estimate in connection with the program plan in 1998, and they did include that small factor in coming up with their estimate, which was in the range of around ten to the minus six. It was at that time where we did a similar probability estimate for the rod drop in the BWR, concluded that it was significantly lower than the rod ejection probability in the PWR and at that time switched our attention from the BWR rod drop to the BWR power oscillations. So that's how we got onto the power oscillations in terms of the high burnup fuels work.

VICE CHAIRMAN BONACA: I think you should stay away from probabilities. I mean we just had a recent even in a plant where we could have gone back to power without realizing that there was something up there, and you would have gone critical at zero power --

MR. ROSEN: I don't see that as a reason for not accepting the fact that plants don't stay in this condition.

VICE CHAIRMAN BONACA: I agree with you.

MR. POWERS: Let me just remind my probablistic colleagues that at the Chernobyl Plant there was a prescription of operating at low power, absolutely forbidden to operate at low power. Things that people don't like to do they sometimes do.

MR. ROSEN: What country was that in?

CHAIRMAN APOSTOLAKIS: So this Slide 6 is going to take forever, huh?

MR. CARUSO: Slide 6, no, that's done. That's done. Slide 7.

CHAIRMAN APOSTOLAKIS: So, excuse me, Ralph, are you going to spend all this time on each slide from now on?

MR. CARUSO: I don't need to spend any time on this slide if you want to --

CHAIRMAN APOSTOLAKIS: Okay. Then you go to eight.

MR. CARUSO: Okay. The other Ralph takes over.

CHAIRMAN APOSTOLAKIS: The other Ralph takes over. Okay.

MR. MEYER: I have four slides, and I only plan to speak to the first two.

MR. POWERS: These are the slides that you're going to discuss?

MR. MEYER: The upper half of the first one.

MR. POWERS: Could I ask a question, Ralph? Will the slides that you provide us give us some understanding of why this research is irrelevant?

MR. MEYER: I didn't understand you, Dana.

MR. POWERS: Well, one of the questions we were trying to understand is why NRR considers the research irrelevant.

MR. MEYER: Yes.

MR. POWERS: And I'm wondering if your slides are going to tell us why it's irrelevant.

MR. MEYER: My slides are going to tell you why I think what we're doing is important.

MR. CARUSO: As I explained at the very beginning of my discussion, we consider the use of that word to be unfortunate. And we value the work that is done by the Office of Research, and I don't think I personally would characterize the work as irrelevant.

MR. POWERS: But the fact of the matter is that in the written documentation remains irrelevant; is that correct?

MR. CARUSO: The document was signed, and it's in the document system, and that's correct.

MR. KRESS: I guess the broader question is does NRR still think there is a need for a user need letter on this research?

MR. CARUSO: Actually, then we're going to have to go back to the previous slide.

CHAIRMAN APOSTOLAKIS: This is the fundamental question.

MR. KRESS: Yes. Let's go back to the previous slide.

CHAIRMAN APOSTOLAKIS: This is the question that needs to be answered.

MR. CARUSO: The user need process in the Agency right now evaluates -- user needs are evaluated against these four criteria. These are the four Agency pillars: Maintaining safety, improving efficiency, reducing unnecessary regulatory burden and improving public confidence. Until last Thursday, we had no licensing actions under review which required the results of the research --

MR. WALLIS: I'm sorry, Ralph. Do you think your broad brush curve satisfied Criteria 4? And if it doesn't, what are you going to do about it?

MR. CARUSO: Well, what we do is we evaluate against all four of the criteria.

MR. POWERS: How do you do that? How do

you evaluate Number 4?

MR. CARUSO: We have decisionmakers who sit around in a room and talk about it.

MR. POWERS: Maybe you should make your presentation to some intelligent technically knowledgeable members of the public, see if that works.

MR. CARUSO: Well, all I can say is this is what we do. And we rank each proposed user need against these criteria.

CHAIRMAN APOSTOLAKIS: But the criteria are not equally weighted.

MR. CARUSO: They are equally weighted, at least in NRR they are. NMSS, I believe, has weighting factors for different criteria.

CHAIRMAN APOSTOLAKIS: Maintaining safety and improving public confidence is equally weighted?

MR. CARUSO: Well, in NRR right now the criteria are weighted equally.

CHAIRMAN APOSTOLAKIS: See, now we can talk about it forever. I mean which public are you talking about? But, anyway, why don't we let you go ahead.

MR. CARUSO: As I said, until last Thursday, we had no licensing actions under review which required the results of the research high burnup program.

MR. POWERS: That's the one I've never understood on this. It seems to me that you have all kinds of things here. You've got a Regulatory Guide that's in desperate need of amendment. You've got a topical report there that seems to have a fairly interesting selection of criteria. I mean just in your own presentation I think I counted three or four different things that were on your plate that seemed to address them, required information from the Research Program.

MR. CARUSO: Well, this report, as I said, arrived last Thursday. I didn't expect this report to contain the information it does. I expected it to contain information about burnup above 62, not below 61. And the Research Program is not aimed at burnups above 62, it's supposed to be confirming values for burnups below 62.

So in addition, you asked about these regulatory criteria that desperately needed to be revised, and I guess I would take issue with that characterization of the need to revise the Regulatory Guides and the SRP. We know they need to be revised. We want good data to be provided to us, but that data isn't going to be provided to us for at least several more years. And in the interim, I have licensing actions that I have to make that I cannot delay until this information comes out, until it goes through a public comment period, till it comes to the ACRS, several times probably, goes to the CRGR and is debated. I have to make a licensing decision in the interim.

MR. WALLIS: You can turn down --

MR. KRESS: You're also going to have to make licensing decisions later on when you could really use that data.

MR. CARUSO: And I will. I will. I will use that information when it eventually comes out. I'm not saying I'm going to ignore it.

MR. KRESS: Okay. Isn't that a criteria for a user need letter, "I'm eventually going to need this to make better decisions?"

MR. CARUSO: I guess I'm going to go to my bottom line right now, which is to say that the user need program, we recognize, needs some work, and we are in the process of revising it. And this issue will be one of the things that will be considered as part of the revision to the user need process. Agencies try to work on a prioritization scheme for user needs, how to do this in an integrated fashion between the offices, and --

VICE CHAIRMAN BONACA: You know, you could characterize your situation as one that says, "I have to make decisions. Therefore, I'll make decisions with whatever information I have. And what I have I can use." I can understand your position, but --

MR. CARUSO: That's the position I'm in right now.

VICE CHAIRMAN BONACA: Wait, wait. But if I were in your shoes, I would say, "However, I don't have enough information, and therefore I'm hardly -- I'm pressed to have this data as soon as possible." I would feel that way, because what you presented to us wasn't very convincing. And instead you're saying, "I don't have enough information to do the work, but I can live with that, and whenever the information will come, then I will do that. And if it comes in several years --

MR. CARUSO: I would like to have more information, but right now we don't have it.

VICE CHAIRMAN BONACA: The reason why I'm making a comment is that that comment is pertinent to the recommendation to RES on whether the work they're doing is important or urgent or whatever enough to justify stepped up effort or slow down effort or whatever. That's why I'm making an observation. I mean to me, particularly on the part of the users, depending on how you feel pressed for that information to back up what you have, which is not much. Okay? Then that will give some kind of impetus to the work that RES is doing or slow it down.

MR. CARUSO: I'm not sure how much I could speed it up. I mean the CABRI program is proceeding at the speed it's going to proceed, and I don't think I have any effect on whether it proceeds quickly, more quickly or not. Can we make the CABRI program go faster?

MR. MEYER: No.

MR. CARUSO: No.

VICE CHAIRMAN BONACA: No, but you could kill it. I mean --

MR. ROSEN: It's not a U.S. program.

MR. CARUSO: NRR has not taken a position that the CABRI program should be killed. We think this is valuable research.

CHAIRMAN APOSTOLAKIS: What did you say, Ralph, I'm sorry.

MR. CARUSO: It's valuable research.

CHAIRMAN APOSTOLAKIS: Okay.

MR. CARUSO: But then I've got to -- what does the word "need" mean? My management is about to shoot me. What does the word "need" mean? We don't know. This is not a well-defined term.

CHAIRMAN APOSTOLAKIS: So the bottom line then is what?

MR. CARUSO: The bottom line is that this is not a --

CHAIRMAN APOSTOLAKIS: There is no user need.

MR. CARUSO: Under the current definition of "user need," which we have in the office, this is not a user need.

CHAIRMAN APOSTOLAKIS: Was it at any one time?

MR. CARUSO: Yes, it was.

CHAIRMAN APOSTOLAKIS: What changed since that time? The definition of "user need" changed?

MR. CARUSO: You're asking me a policy matter, which I can't address.

MR. HOLAHAN: I can give it a try. This is Gary Holahan at NRR. I think the issue of user need is a confusion factor that we're trying to work into a better process. At the moment, user need really means identifying who's the sponsor, who's responsible for saying, "I want this money spent. I want this agency money spent on this subject and not on other subjects." At the moment, when NRR says this is a user need, we're saying we're responsible. We want this information, and no one else has to justify why this program is being done.

At the moment, NRR says we have, and have had since 1997, interim criteria which provide a reasonable basis for meeting the general design criteria. In fact, many people would say at least 100 conservatism between 100 calories per gram and challenging vessel integrity or probability of the core. And under those circumstances, we could live with the interim criteria.

I recognize that we don't have complete control over these programs. If the Japanese and the French decide to shut down those test facilities and take the interim criteria and go through the process of public comment and all that, those will be the new criteria for the Reg Guide and the Standard Review Plan. We could live with that. That doesn't say there's no value to the research. It doesn't say that it isn't a good thing to do and that we wouldn't use it if the data was generated.

The question is who is causing the data to be generated. Is it because NRR has said, "I need this information whether anyone else wants it or not"? And until last Thursday, I don't think we could say that, because we had an interim position for a low probability event for which we have a very conservative criteria, no clad failure for a ten to the minus six event is the most conservative criteria among accidents. What we've said is last week EPRI and NEI sent us a new report, and when we look at that report we'll relook at the question of what technical support, what research program and what assistance from the Office of Research we need in reviewing that topical report. So each time we have a new set of regulatory issues before us, we go back and we ask that question.

And the question in my mind now is are we in a position to review this topical report and the issues that it puts on the table without additional research? And we don't have an answer to that yet. We just got the report. We'll look at it and we'll reconsider. And it may be that we decide that there's a real user need or it may be that we don't need that and we'll review the report under some other --

MR. POWERS: Gary, you've indicated that you can live with the interim criterion.

MR. HOLAHAN: Yes. And we have been.

MR. POWERS: And what I will point out that based on the discussion for the last 40 minutes, you may be very content with them, but you have a very hard time convincing other people that those are useful criteria.

MR. HOLAHAN: I heard that.

MR. POWERS: So I will draw your attention again to Mr. Wallis' point in your fourth criterion on whether you have a user need or not.

MR. WALLIS: My impression is you have a tremendous user need, unless there's something I haven't heard today that this seems to be a problem that's been going on for a long time, that decisions have been made based on very tenuous information. Now maybe I'm completely wrong. Maybe you've given me completely the wrong impression, but that's the impression that's given.

MR. POWERS: What I will point out to you, Graham, is that this decisionmaking that went on was presented to this Committee. This Committee has supported it, but with the caveat that there was a strong Agency plan supported strongly by NRR with a user need to conduct the research to validate that. And now that component that led to a fairly enthusiastic endorsement of what was going on seems to be missing here.

MR. KRESS: I think we've discussed this a lot. Can we wrap it up pretty fast, Ralph?

MR. MEYER: Could I suggest that maybe you just view the slides, and if you don't want additional presentation, I'd be happy to go quickly or just not at all.

MR. POWERS: Well, let me just ask you this question, Ralph. Your slides are indeed fairly explicit, but at what point -- do you have any insight right now on what point it would be useful for a Reactors Fuel Subcommittee to assemble and look at your program again?

MR. MEYER: Yes. I think it's time very soon for that. We have been doing that about once a year.

MR. POWERS: Right.

MR. MEYER: And we didn't schedule one this spring. So I think we should. There have been developments in the last year that are significant, and it would be a good idea to do that.

MR. POWERS: Yes. I think that just anticipating the ACRS' obligations, we are obligated this year to produce a fairly comprehensive research report, and it would be useful to have a meeting so that we can prepare this section of that report. So maybe if you guys can find a time that's convenient. I don't want to hit you at a time when everything's chaos and whatnot, but some convenient time maybe we could find a mutually satisfactory time to do this, because just looking at your slides there's a lot of interesting stuff.

MR. MEYER: I would suggest that the Subcommittee might also want to look at the EPRI topical report.

MR. KRESS: That's a good idea.

MR. MEYER: And I think within a few months the staff will have time to look at it and generate some positions, and in fact you might want to hear from them as well.

MR. POWERS: Maybe some coordinated thing between the two of them.

MR. MEYER: That would be a good idea. We've had that happen before.

MR. POWERS: As long as we have the information so that in the fall of this year we can prepare our research report, that would be useful.

MR. SIEBER: I'd also like to ask a favor. The three slides that you used that were graphics, if you could make us copies and provide us a copy.

MR. CARUSO: I'll get them.

MR. SIEBER: The other thing, I noticed that the one slide which you said came from Westinghouse, is that proprietary?

MR. CARUSO: It's not proprietary. The document itself is proprietary, but this page is not marked.

MR. SIEBER: Okay.

MR. CARUSO: It doesn't have the brackets around it that indicate proprietary. And I specifically asked them if I could do that. It's not actually proprietary.

MR. KRESS: I want to thank the speakers. This was a useful exchange of views, I think. And we appreciate you coming down. With that, I'll turn it back to you, Mr. Chairman.

CHAIRMAN APOSTOLAKIS: Thank you. I don't think we will need transcription for the next session. Thank you.

(Whereupon, at 2:26 p.m., the ACRS meeting was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: 492nd ACRS Meeting (Open Session)

Docket Number: N/A

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

/s/ Debra Wilensky
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