UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

***

BRIEFING ON HIGH-BURNUP FUEL ISSUES

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PUBLIC MEETING

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Nuclear Regulatory Commission
Room 1F-16
One White Flint North
11555 Rockville Pike
Rockville, Maryland

Tuesday, March 25, 1997

The Commission met in open session, pursuant to notice, at 10:04 a.m., the Honorable SHIRLEY A. JACKSON, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
KENNETH C. ROGERS, Member of the Commission
EDWARD McGAFFIGAN, JR., Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, Secretary
KAREN D. CYR, General Counsel
JOE CALLAN, EDO
DR. CARL PAPERIELLO, Director, NMSS
THOMAS KING, Deputy Director, Division of Systems Technology, RES
GARY HOLAHAN, Director, Division of Systems Safety and Analysis, NRR
RALPH MEYER, Senior Technical Advisor, RES
HAROLD ORNSTEIN, Reactor Analysis Branch, AEOD

P R O C E E D I N G S

[10:02 a.m.]

CHAIRMAN JACKSON: Good morning. I am pleased to welcome members of the Staff to brief the Commission on high-burnup fuel issues.

Greater economic competitiveness is causing the nuclear power industry to pursue various changes. Among those are longer fuel cycles and high burnup fuels. This morning the Staff will discuss its activities in the high-burnup fuel area and describe any safety concerns raised by information derived from reactivity insertion experimental test results in other countries including France, Russia, and Japan.

The Staff will describe how these experiments are being followed up and what impact they have on issues of safety in U.S. nuclear reactors.

The Commission is interested in hearing how the Staff is integrating information from research including the results of tests and analysis done by the international community and domestic operating experience and how this information is being used to ensure that plants are operating safely and in conformance with their licensing basis.

The Commission is also interested in hearing about the appropriateness of our current fuel damage criteria for

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reactivity insertion events.

My understanding is that the Staff will discuss the status of the research program on high-burnup fuel and the adequacy of our codes to account for high-burnup effects.

The research program to date has focused on high-burnup fuel response to reactivity insertion accidents, but there are other considerations. For example, high burnup fuel response under design basis analysis, loss of coolant accident operational transients and shortcomings in criticality and reload analysis for cores using high-burnup fuels.

The Staff should describe progress being made in these areas as well, so we look forward to your briefing today and I understand that copies of the viewgraphs are available to the entrances to the room.

Mr. Callan, please proceed.

MR. CALLAN: Thank you, Chairman. Good morning. Good morning, Commissioners.

The last communication with the Commission on issues surrounding high-burnup fuel was a memorandum to the Commission dated November 25th, 1996.

Today's briefing will pick up from that November memorandum and summarize NRC work related to high-burnup including our plans for the resolution.

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At the table with me are representatives from all four major technical offices, since the high-burnup fuel issues impact activities in all four offices.

To my left are Tom King and Ralph Meyer from the Office of Research. Their presentation summarizes the NRC research program designed to obtain the relevant data to assess the behavior of high burnup and MOX fuels.

To my right is Gary Holahan, representing the Office of Nuclear Reactor Regulation. Their presentation summarizes the U.S. operating experience in NRC regulatory action.

Also to my right is Hal Ornstein, representing the Office for Analysis and Evaluation of Operational Data. The AEOD summarizes international operating experience.

Also to my right is Carl Paperiello, representing the Office of NMSS, the Nuclear Materials Safety and Safeguards Office. Their presentation summarizes emerging issues relating to fabrication and transportation of fresh fuel and storage and transportation of spent fuel.

The Office of Research has played a prominent role in preparing this presentation and overall in addressing some of these issues, so I want to turn this meeting over to them to introduce the technical presentations and to summarize the overall status at the end. Tom?

MR. KING: Thank you, Joe.

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If I could have Slide 2, please.

[Slide.]

MR. KING: Slide 2 shows the outline of our presentation this morning. As Joe mentioned, the purpose is to update the Commission on issues related to high-burnup fuel performance and the Staff activities to address those and this is a followup to the November 25th, '96 memorandum. That memorandum focused on two prominent issues, primarily the control rod insertion issue and the fuel performance related to reactivity insertion accidents.

However, high-burnup affects a lot more than those two areas and today we intend to take a more comprehensive look at the issues and the activities that are underway to address those issues.

Accordingly, that is why we have all four offices involved, because we are -- it is an integrated activity and we want to --

CHAIRMAN JACKSON: Who is integrating? Who is the point person? I mean who has the responsibility to ensure that the activities in fact of the different offices properly inform each other and are integrated?

MR. KING: Well, I think we have been trying to do that at the division level. Certainly, within Research our counterpart is Gary Holahan and his people and we work closely with them --

CHAIRMAN JACKSON: No, I understand what you are telling me but I guess what I am really asking you is is there a lead individual with respect to the activity so that, you know, everything informs everything else?

I mean I understand that you have been looking at international, you have been looking at domestic, you look at specific fuel issues, and I am probably somewhat more familiar with what you have been doing in the research area, but a concern is to have some coherence, so is there an individual identified who has the lead in this?

MR. KING: At this point I don't think we have one individual identified.

CHAIRMAN JACKSON: Okay, so it is kind of an emerging activity?

MR. KING: It is an emerging activity. As I said, we are trying to integrate it at the division level among the offices.

CHAIRMAN JACKSON: Okay.

MR. CALLAN: Chairman, we will look at that. That is both good and an obvious thing that we ought to be looking at and we'll make a recommendation.

MR. MEYER: Could I jump in here and say --

CHAIRMAN JACKSON: Sure.

MR. MEYER: -- we do have this generic issues management system.

It is identified as a generic issue and I am the Manager for the generic issues so there is some coherence at least at the working level right now.

CHAIRMAN JACKSON: I understand that. That is a separate question.

MR. KING: Okay.

CHAIRMAN JACKSON: But anyway, good, Joe. That keeps me from having to put it in my closing remarks.

MR. KING: Okay. The handout is a fairly thick package. What we intend to do today is not show every viewgraph. Some are provided here for information, so we will be skipping over some and just hitting the highlights.

If I could have Slide 3, please.

[Slide.]

MR. KING: What I want to talk about for the next few minutes on the next three slides is provide an overview of the issues and then a little bit of background as to what led up to these issues.

We have broken down the fuel performance issues into two basic categories, in-reactor and out-of-reactor we have labelled them. However, qualitatively many of the issues are the same. For example, cladding integrity is important in-reactor and out-of-reactor.

As you mentioned, Chairman Jackson, high-burnup fuel represents a trend in the industry to reduce costs of

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electricity production and it is being done in conjunction with things like longer operating cycles, reducing storage costs, and also things like power operating.

To achieve improved fuel performance the industry is pursuing several things. They are looking at new cladding materials. They are looking at higher enrichments. They are reducing some of their operating margins and they are radiating materials for longer periods of time.

High-burnup was also leading to certain changes in certain fuel characteristics. Among these are higher cladding oxidation which leads to embrittlement of the cladding, higher fission gas release which leads to higher pin pressure and higher source term fission gas release source term component.

We are seeing different thermal and physical characteristics of the fuel, for example, fuel conductivities changing. We are seeing fuel fragmentation take place as the burnups get higher. We are seeing a shift in some of the failure modes of the fuel. We are seeing certainly the higher radionuclide inventory as decay heat builds up with higher burnup.

These things have led to some unexpected results, some of which you are aware of -- the failure at low energy inputs from the French tests and Japanese tests on reactivity insertion accidents, control rod insertion

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problems at some plants in the U.S. as well as overseas.

We are seeing some different failure modes, as I mentioned, cladding, brittle cladding failures, and fuel expulsion in some of the tests, and we are seeing larger fission gas released from fuel, higher than had been expected.

All of these things indicate that we need to look at our codes and criteria to update them and evaluate their current applicability to high burnup and all of these things also affect a number of areas. They affect normal operation. They affect anticipated operational occurrences and design basis events and analysis that we do in the severe accident area.

These things are shown on Slide 3, if I could have Slide 3, please.

[Slide.]

MR. KING: Traditionally fuel cladding has been the first barrier in what we call defense-in-depth and the criteria we had developed many years ago to deal with fuel integrity had generally kept the risks from fuel failure low during normal operation, anticipated operational occurrences, and design basis events.

[Slide.]

MR. KING: The criteria, on Slide 4, we have shown the criteria pictorially. They have been established

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basically for normal operation and anticipated operational occurrences. The intent of the criteria are to maintain cladding integrity and basic -- and allow, provide for safe shutdown of the reactor and basically they correspond to no release of fission products to the environment.

For postulated accidents, which include reactivity insertion events, loss of coolant accidents, the criteria are directed toward maintaining safe shutdown, coolable geometry and the applicable criteria are the Part 100 dose guidelines that have to be met during those accidents.

For severe accidents we don't have any limits on fuel integrity but clearly the fuel performance affects the source term and the core melt progression. That is assumed in risk assessment.

CHAIRMAN JACKSON: Let me ask you this question. Of the postulated accident conditions that you have on Slide 3, which are the greatest contributors to risk?

MR. KING: It's somewhat plant-dependent. In some cases we see LOCAs as the biggest -- as larger than the others in contributing to risk. In other cases we see a contribution from ATWS. Never have I see the rod drop or rod eject accidents be a prominent contributor to risk.

MR. HOLAHAN: And the contributions are not from the design basis ATWS or LOCA, which is a mitigated event, but it is the related severe accident.

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CHAIRMAN JACKSON: Right, severe accident, and where have we been focusing our attention to this point?

MR. KING: Our attention from the experimental programs that are underway have been on the rod drop and rod ejection accidents. We are now shifting that focus to LOCAs and the ATWS.

Of the criteria that have been developed and are currently in place, developed a number of years ago, based upon data from primarily tests with fresh fuel and fresh cladding or cladding and fuel that had achieved low burnup. It had also been based upon zircalloy and zirlo cladding, and with the new cladding that is being developed by the industry, some of the properties are clearly going to be different than what has been used in the past to establish our criteria, so the goal of our work is to continue to assess our criteria and our codes so that we can assure that the risk remains low from fuel performance issues.

We don't think there is immediate safety concern in this area for several reasons.

One, the accidents remain low probability.

Two, it takes time to achieve high-burnup.

Three, we think from the data that we have received to date and the direction we feel the criteria are going to go, we feel that plants will be able to -- like be able to meet these criteria once we get the revisions made

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and get them in place.

CHAIRMAN JACKSON: This is kind of a curve ball, but is it true that there was an observation with MOX fuel in Europe that at low-burnups then what we consider to be high-burnups with uranium dioxide based fuel, that there was some fuel damage for, you know, an energy insertion where we wouldn't have expected it?

MR. KING: Yes, there was a recent test in France, I believe. Maybe Ralph could --

MR. MEYER: Can I take this? This was a test in the test series in the CABRI reactor in France.

The fuel rod did have a fairly high-burnup. It was 55 gigawatt days per ton. What they have been testing to in that same test series has been a little higher, up around 60-63 gigawatt days per ton.

I personally thought that the failure that occurred in this test was totally expected. It failed around 110 or 120 calories per gram during a reactivity transfer, which is exactly where I think the rest of the data are telling us the failure should occur.

What did happen was that there was a larger pressure pulse generated in this test than in other tests but it had a total energy deposition that was higher than the other tests they had performed so there is some concern that the microstructural changes in the pellet due to having

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more plutonium in there may lead to additional fragmentation and some increase in this fuel-coolant interaction that leads to the pressure pulses, but at this point I think that remains to be seen.

I thought it was a pretty normal test but I know even the people that performed it were a little surprised at the energetics of it.

CHAIRMAN JACKSON: Thank you.

MR. HOLAHAN: I think what all of this experience has at least taught me is it's really the condition of the clad before the test or before an accident that's the primary driver of whether it fails or doesn't fail during the test. And then I think there are other contributing considerations like where the energy is being generated in the fuel pellet and the fact that MOX fuel has a little bit different reactivity characteristics. I think largely what we're seeing here, the low-energy failures are because of the condition of the cladding. That's the primary issue.

CHAIRMAN JACKSON: Okay.

COMMISSIONER McGAFFIGAN: Could I ask just in a clarification, when you use numbers like 6 -- 60 gigawatt days per metric ton, is that batch average, peak, rod, what -- just so you all stay on the same language all through the briefing.

MR. MEYER: When we talk about an individual test,

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it's the actual burnup in the test section that's being tested. These test sections are a little over a foot long, and they come from locations in the rod where the burnup profile is pretty uniform. So when we talk about a specific test it will be for the fuel in that test. It's fairly constant. You'll see that requirements are often quoted in different units, and it makes a pretty big difference. The French, for example, talk about their limit at 47 gigawatt-days per ton. This is an assembly average number, whereas we talk about our limit at 60 gigawatt-days per ton, and that's the average for the peak rod. There's about a 10-percent difference in the unit.

CHAIRMAN JACKSON: Okay. Tom.

[Slide.]

MR. KING: Okay. Slide 5 summarizes the out-of-reactor fuel issues, and as I said earlier, qualitatively many of these are the same as the in-reactor issues.

Cladding integrity is important in the outer reactor area, the higher decay heat, you'll need the higher cladding temperatures, clearly the higher oxidation that occurs in the reactor is an important consideration out of reactor.

The higher pin pressure that occurs due to higher burnup is a consideration in any out-of-reactor issues.

The source term is another common issue due to the

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higher radionuclide inventory, the potential for fuel dispersal upon cladding rupture, shielding issues.

Criticality is an issue, both in the fabrication and the transportation and storage side.

So even though qualitatively many of the issues are similar, when you get out of reactor you're also talking about differences in time scales at which you're looking at the performance of the fuel as well as the descriptions of the types of accidents that need to be considered.

If we could go on now to --

COMMISSIONER ROGERS: When you say something's an issue, what do you really mean by that? Do you mean that it's something that we don't have adequate data on or adequate data don't exist, or it's just something that has to be carefully included as one moves into higher enrichments but that basically what needs to be known is already known?

MR. KING: It could be some of both. Basically when we identify things as issues in the beginning, they are areas that we feel are affected by higher burnup that we need to look into. In some cases we find there are data, sufficient data to upgrade a code or revise criteria. In other cases we find out there aren't and we need to figure out a plan or a strategy to get that data.

COMMISSIONER ROGERS: Well, I wonder -- excuse me.

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CHAIRMAN JACKSON: That's all right.

COMMISSIONER ROGERS: During your presentation at some point before we all go home whether you couldn't touch upon those issues where really additional data or research are needed that just simply doesn't exist.

MR. KING: Yes. We're going to cover that as we get to the -- Ralph covers the research program, Gary covers the NRR activities, and Carl the NMSS activities. So we'll cover that.

COMMISSIONER ROGERS: Right.

MR. KING: We can go to slide 7.

[Slide.]

MR. KING: Slide 7, you know, in a box diagram shows the major components of the fuel research program that exists today. It's broken out into three main areas that deal with reassessing the criteria, updating the codes, and getting experimental input to support these activities.

We also have another activity in the criticality area looking at extending the criticality codes that are used for fuel fabrication to higher enrichments.

And then up in the upper left-hand corner of the slide I have a little item called mixed oxide fuel white paper. That's an initiative we're undertaking in house in research to do some homework in case we get involved in reviewing applications for mixed oxide fuel, and basically

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it's to look at what do we know from past work, what do we know from what's going on overseas, and what are the issues that we need to deal with if we get into a mixed oxide review.

That's all we're really going to say about mixed oxide. The rest of the presentation is going to concentrate on the activities under way dealing with the operating reactors today, and I'm going to turn it over to Ralph to talk about --

CHAIRMAN JACKSON: Before you do that, if you look at these boxes on page 7, does that cover the full scope of issues that --

MR. KING: That research is looking at; yes.

CHAIRMAN JACKSON: Right. No, not that you're looking at, but that have been identified.

MR. KING: I think the one area that we're looking at that's really not in the research program --

CHAIRMAN JACKSON: Okay.

MR. KING: Is the difficulty with incomplete insertion of control rods, and we're dealing with that through operating experience with the vendors, not really through a research program.

CHAIRMAN JACKSON: Okay, so you're going to talk about that.

MR. KING: Yes.

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CHAIRMAN JACKSON: Okay.

MR. KING: I think there may be some things that come out of NMSS that may expand the scope of research activities as well, and we'll talk about that.

CHAIRMAN JACKSON: Okay. Thanks.

MR. KING: Ralph will now describe the research program.

MR. MEYER: Let's stay with slide 7 for just a minute, because these are the main elements of the program, and let me just touch on each of these before going on.

First of all, look at the center box at the bottom of the page where it talks about updating our analysis tools. We actually started this work before we had results from CABRI or the control rod sticking problem came up, so we had begun to modify the codes, and I'll give you some additional details on the code work on a later slide.

CHAIRMAN JACKSON: You are going to address the question of whether NRC codes can adequately predict fuel and clad behavior at the burnups now being used by --

MR. MEYER: Yes, I can do that. I can do that right now and say that the three codes that the NRC uses that specifically deal with fuel behavior are the three listed here. The first one is a steady-state fuel behavior code. FRAPCON is an evolution of an older code, GAPCON, that many people have used.

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This code and its predecessor are used routinely in licensing reviews because one of the main outcomes of these reviews depends critically on something you calculate here, that is, the loss-of-coolant accident analysis, the ECCS behavior is very strongly dependent on the stored energy that's in the fuel rod at the beginning of that accident. That's calculated in detail with this code, each of the vendors has a reviewed corresponding code, and this code is used as an audit tool to check their work.

This code has been updated to handle burnups up to at least 65 gigawatt-days per ton. That work has recently completed -- the final peer-review meeting on that code is next week, and the release of the code will follow as soon after that as we can respond to any things that come up in the meeting next week.

The transient code is not used routinely in licensing but it's used from time to time for special studies, and also particularly for analyzing experimental results. We are just under way in making revisions to that code. We kind of have to do these one after another because it is the same contractor and we don't have many people working in this area these days. So that work is under way and will take a year or so. But we're still able to use the code during this time if we know exactly where its deficiencies are and can keep an eye on them.

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The RAMONA code, transient neutronics code, has been used for our high-burnup calculations, and it does have some significant uncertainties associated with high-burnup applications, and we have looked into those uncertainties. We have not made any adjustments yet to the code for that.

CHAIRMAN JACKSON: So that's the third in a row? You said you had one contractor.

MR. KING: No, I'm sorry. You can't read my mind.

No, we actually have two contractors. We have one for the thermal mechanical fuel behavior codes, and a different one for the neutronics code. That work has been going on simultaneously.

CHAIRMAN JACKSON: Okay.

MR. KING: Okay. So at about the same time we started the code work, this was about 4 years ago, we also started looking at the acceptance criteria that we use in regulatory work that related to fuel behavior. I think of these as speed limits that are related to fuel behavior. And we'll talk more about those as well.

So that's sort of assessment work, and then we have some experimental programs. Now most of our experimental work at this time is brought in from overseas. All of the work on the reactivity accidents, the recent work, was done overseas. Of course we have a tremendous amount of work in our historical existence on this in the

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old Spartan PBF reactors. And we have in fact gone back and looked at those data as well.

But as you saw earlier in the discussion, the loss-of-coolant accident in our view is at least as important, probably more important, than the reactivity accident from a risk point of view, and so we decided that there was not enough work, experimental work, being done on the loss-of-coolant accidents, and is something where we still have the expertise in the U.S. and where we can get in the game and actually do some experimental work. So we have initiated a program. I'll talk about that briefly on a later slide.

The Halden program in Norway is providing sort of baseline thermal properties for the computer code development, and we utilize those data.

Finally then on the mixed oxides, what we plan is in the near future to do a sort of review, a white paper, on the effect of the mixed oxides on all of the same things that we're looking at at high burnup. These will be I expect modest effects rather than huge effects.

MR. HOLAHAN: If I could go back to your earlier question, Dr. Jackson, I think it's fair to say that the experimental data is in some sense used in developing or verifying at least the first two codes, because the steady-state analysis can be compared with Halden, and the

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transients analysis can be compared with the tests. The 3-D neutronics really don't have, you know, an experimental facility to be compared to, but there are code-to-code comparisons that are done to give you some comfort in the capability of that code.

MR. MEYER: Okay, slide 8.

[Slide.]

MR. MEYER: Well, the objective in a word is to maintain the technical expertise here that we need, and I'm not going to dwell on any of this, but you'll see that in doing this that our work is focused on the in-reactor issues, and here we have made a distinction in the past. We've talked about technical issues versus regulatory issues, and -- but we've focused our work on the technical issues where questions arise that might have a regulatory impact is where we have turned the spotlight, and we've done this by trying to keep our codes up to date, getting data from other programs, as I mentioned, we have a lot of involvement with the international programs, and we also have some recent initiatives with industry groups and DOE to try and get some cooperation going. We'll mention more of that in just a minute.

CHAIRMAN JACKSON: Let me make sure I understand. What NRC regulatory criteria, you know, fuel --

MR. MEYER: Okay.

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CHAIRMAN JACKSON: Or burnup damage limits might be affected by --

MR. MEYER: Okay. If you think about that pyramid from slide 4 or 5, whatever it was, for each of the design-basis accidents, and there's just a handful of design-basis accidents that we use in licensing, the most prominent of those is the loss-of-coolant accident. So let me talk about the loss-of-coolant accident for a minute.

The main speed limit or regulatory criterion in the loss-of-coolant accident is that after you go through this big transient that you maintain the coolable geometry of the core. And you do this by demonstrating in an analysis that the peak cladding temperature remains below 2,200 degrees Fahrenheit and that the oxidation that occurs during that transient remains below 17 percent of the wall thickness being oxidized. That's the way it's laid out in 10 CFR 50.46.

Then you have models that you have to use to calculate those things, and those models involve the oxidation kinetics, the occurrence of rupture of the cladding, the amount of strain, how big does the balloon grow, and how much blockage does this cause in the core. All of these things are affected by the ductility of the material and its mechanical properties, which are in turn affected by the fluents and the oxidation that it gets as it

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goes to higher and higher burnups.

And all of the testing that was done to establish the 2,200 number, the 17-percent number, the Baker-Just oxidation kinetics that have been used extensively, and the models that are embedded and improved and stamped and locked in the vault for these codes were all based on tests with fresh fuel rods back in the seventies.

CHAIRMAN JACKSON: Okay.

MR. KING: For example, the concern is you get a lot of oxidation as you proceed to higher and higher burnups. That tends to eat into the 17-percent criteria that's in the regulations. The cladding becomes embrittled. You don't get the balloon and rupture type failures anymore with the brittle cladding. So we're looking into what kind of failures are we going to get and do we need to change our criteria or not.

MR. MEYER: Now, there are also criteria for the rod drop -- rod ejection accident, there are a whole bunch of criteria for the normal operating regime, 1-percent cladding strain, fuel rod pressures versus the system pressure, lots of little things, but the big one gives -- I think characterizes the situation.

MR. HOLAHAN: There's one additional difference, and that is for the LOCA the criteria and the methods of analysis are pretty much in the regulations. In most of the

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other areas the regulations call for some requirement, but in most cases they don't specify what the criteria ought to be or how to do the calculation. And so there's either a regulatory guide or a case-by-case review to establish those.

CHAIRMAN JACKSON: Commissioner McGaffigan.

COMMISSIONER McGAFFIGAN: Could I ask how high are we prepared -- is our research program aimed at looking at burnups? The DOE program that may or may not be funded by Congress says one of its goals and objectives of the spent-fuel minimization R&D program is to reduce the amount of spent fuel generated in nuclear powerplants. The principal areas of research include resolving technical issues with current high burnup fuel at 60 gigawatt-days per metric ton, developing fuel performances supporting 100 gigawatt-days per metric ton burnups, and analyzing, et cetera.

Do we have anything in our codes or our research experience that if DOE were to pursue that program we'd be able to be comfortable with 100 gigawatt-days per metric ton? I assume that's peak rod burnups.

MR. MEYER: We are familiar with the DOE proposal and the degree of cooperation that would exist would provide us with the basis for making the adjustments that we need to make, but we are not at this time moving toward 100 gigawatt-days per ton. We are operating with peak rods in

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the neighborhood of 60 to 62 gigawatt-days per ton. There's probably a need for a little elbow room there, maybe, I don't know, 65 or 70, and I think when you see the underlying phenomena that take place as you accumulate burnup that you can develop the ability to extrapolate a little bit.

I mean, what we see is the breakaway oxidation phenomenon that occurs around 40 to 50 gigawatt-days per ton, and this is the culprit. This is why the earlier requirements which were based on data out to around 40 gigawatt-days per ton didn't just work at higher burnups because something happened. We know what happened now, and of course there would be the question if you get up to 100, is something else going to happen, and you would indeed need a data base, but if, you know, if DOE goes forward with that program, the program itself is to generate that data base.

COMMISSIONER McGAFFIGAN: But that would also as I understand it -- what the goal, since this is called waste minimization, would be to be able to keep for three cycles -- three 2-year cycles -- the rods in, you know, a fresh rod being able to stay in for three 2-year cycles in a reactor rather than two, which is typical I guess today, and to do that they'd have to go to 7 percent enrichment, as I understand it, if they were going to get all the way to that, how far are you extrapolating or how much -- if they

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pursue that program, I guess I'm basically asking what do we have to do and what costs are there going to be for us to sort of stay abreast of it and be ready to act on it should somebody come in and ask us to act on it?

MR. KING: We haven't sketched out the costs that would be associated with trying to respond to the DOE program. We currently have steady-state irradiation data out to the low seventies in terms of burnup, and we have transient data particularly for the RIA's out to the mid-fifties, low sixties. If DOE is going to go up to something like 100, we currently don't have the data, and we have --

CHAIRMAN JACKSON: Is it also based on enrichments of 5 percent or less?

MR. KING: Yes. The French and the Japanese tests are based on enrichments of 5 percent or less. The Halden steady-state data that goes up to the low seventies I'd have to check, but if it's greater than 5 percent, it's probably not much greater.

COMMISSIONER McGAFFIGAN: Is there anyone else in France, which is a leader in I guess this area, or at least -- or Japan or whatever -- who's looking at trying to get to these sorts of waste-minimization goals. This partly comes up, Madame Chairman, because, you know, in this convention on waste that's being negotiated at the moment, this notion of waste minimization is in there, and we don't

have much of a -- it's not really in our regulatory framework, and I'm trying to understand whether, you know, there's going to be impetus as a result of this waste convention should it be negotiated for us to do something like this to meet a waste-minimization objective of some sort.

MR. KING: I don't know of any overseas program that's trying to -- has the goals of the DOE waste-minimization program.

CHAIRMAN JACKSON: The same countries that we might look to to get the data also happen to be ones that reprocess, and that's also part of their waste-minimization strategy.

MR. KING: When we get to the last slide on concerns you'll see one of our major concerns is the impact of this DOE waste-minimization program on --

COMMISSIONER McGAFFIGAN: Okay. I'm sorry to have jumped the gun.

CHAIRMAN JACKSON: No, no, no; that's a good question.

MR. HOLAHAN: I think it's also fair to say that our experience to date has taught us that what we should be doing if increasing burnups at all is to be doing it in measured steps, and long before we thought about anything like a hundred, I think we need to think about 65.

CHAIRMAN JACKSON: Why don't we let you get through a few more viewgraphs, because I think we always seem to preempt what you may have had in mind.

[Slide.]

MR. MEYER: Okay. Well, look at slide 9, and I think that we already talked about almost everything on this page as a result of some of the early questions, so we can move on, and we're skipping 10 and 11, so that moves us right to the schedule.

A few comments about the reactivity-initiated accidents. These programs that we've been talking about in France and in Japan are in my opinion at a point now where we're on a plateau of understanding, and it's going to be 3 to 5 years before they're able to reset these programs, revise their hardware, and get improved data. So we did an interim assessment of all of the data, and in fact issued a research information letter summarizing these data and suggesting some revised criteria for this accident. That was issued just on the 3rd of this month.

New test results are hoped for from both programs in France and Japan. In France in particular I'm sure you've heard talk of this water loop that they're hoping to construct and do tests in that would be much more typical than the current liquid sodium loop. So, you know, in about 5 years I expect that we would have a significantly improved

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data base and can go back and revisit that. But I think we've provided a technical basis for an interim position should we decide that such an interim position is warranted.

Loss-of-coolant accidents, our work is under way. We are working with EPRI and DOE. They intend to help us identify and acquire specimens of fuel rods burned to high burnup in commercial U.S. power reactors, and will share some of the costs of acquisition of the specimens and the shipping and initial preparation, but then of course we'll run our own program when we get them up to the hot cells.

That work will include both loss-of-coolant simulation tests and also some general mechanical properties testing over a range of transient conditions that should be -- that we intend to be applicable both to the loss-of-coolant-type transients, the reactivity-type transients, everything in the range of the accidents and transients that we have to look at in our safety analysis.

Also anytime you work with irradiated fuel rods it's kind of slow going, so this is a 3- to 5-year program to get significant results as well.

The anticipated transients without scram, the ATWS, there's one ATWS, the BWR power oscillation, that we're going to look at analytically. At first we're just going to try and size it up. It does have some rather large power oscillations. The timing of those is quite different

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than the timing in the pulse of a rod-drop or rod-ejection accident. So at this point it's not clear whether the data that have come from these pulse tests can be applied to the power oscillations, and that's what we're going to try and shed some light on with some calculations that we can do in the near future, and we're going to do that.

CHAIRMAN JACKSON: No experimental program?

MR. MEYER: Nothing planned.

MR. HOLAHAN: We are also and over the last few years have been working with the BWR owners' group on their emergency operating procedures to minimize the likelihood that unstable oscillations would occur during an ATWS, so we're looking at prevention at the same time that we're looking at the potential consequences of power spikes if they would occur.

MR. MEYER: And finally the source term is this fall we're going to begin looking carefully at source-term issues. There will be some small changes in gap inventory, the fuel particulate size will be different, there's some shift in the isotopics, but in general I would characterize our expectation as a small step change in going from the new NUREG 1465 source term to one that accounts for a high burnup compared to the big step that was taken between the old TID source term and the 1465.

CHAIRMAN JACKSON: But at this point the new

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source term does exclude high burnup fuel?

MR. MEYER: That's correct.

Okay, Gary Holahan from NRR is now going to talk about the NRR activities on high burnup fuel.

MR. HOLAHAN: Slide 14, please.

[Slide.]

MR. HOLAHAN: The general industry trends have already been mentioned by Tom in his opening remarks. I don't think I need to go over those again.

CHAIRMAN JACKSON: Let me ask you one quick question.

Are we able to adequately audit industry core reload analysis for high-burnup fuels and how do we ensure that safety margins are maintained with different fuel designs and changes to fuel designs at high-burnup conditions?

MR. HOLAHAN: We really have a program that has a number of pieces to it. One is that when a new fuel design is proposed, usually from the vendor is some sort of topical report, the Staff does review and approve that and looks at many of these issues -- cladding stresses, the effect of increased burnup, lead test assembly program to demonstrate what is included in the analysis.

In addition, the Staff will review and approve individual reload analyses where there are changes in the

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technical specifications so at that point we would review changes in fuel design or changes in methodologies and we would review the codes involved at that point.

What we have really been stressing in recent years is a shift from that sort of review and approval mode into more of an inspection type activity and so over the last few years we have inspected all of the fuel vendors. I think over the last approximately two years we have done about nine major inspections at GE, Westinghouse, ABB, CE, Siemens, and we have also --

CHAIRMAN JACKSON: Now how does that track to actually dealing with the industry core reload analysis?

MR. HOLAHAN: In many cases -- reloads are really done in two ways.

Some licensees do their own analysis. Many of them rely upon --

CHAIRMAN JACKSON: The vendors?

MR. HOLAHAN: -- the fuel vendor to do the analysis, so as part of our inspection of the fuel vendor activities we not only look at, for example next week we are looking at Siemens and their fuel manufacturing activities, but last week at Siemens we were looking at their codes and thermal hydraulic analysis.

So we look at --

CHAIRMAN JACKSON: We look at the adequacy of the

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codes.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: We look at how much they are extrapolating beyond existing data.

MR. HOLAHAN: On an audit basis, yes. Now recognizing that for example we may only spend one week with a few experts to go and look at a code, so we can't cover 100 percent of what is in those codes but we do try to select those areas that seem to be significant.

We use not only experienced inspectors and QA qualified inspectors but we also use our own thermal hydraulic experts -- the people in this building who are actually capable of running loss of coolant accident or RAMONA type calculations. Those people are actually out looking at the vendors' comparable analyses from a very technical point of view.

CHAIRMAN JACKSON: Okay, but I guess what I am really trying to get at is this, you know, when I was listening to Mr. King here, I guess I am trying to get at the issue of the adequacy of the codes as opposed to what they do -- that is, are we really looking at the adequacy of the codes or the regions of concern with respect to high-burnup?

MR. HOLAHAN: Well, I have to say we do it selectively.

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We look at various codes in different ways. It's probably fair to say that LOCA analysis gets more attention than other areas, and so for example we do things like in both our review and inspection activities we ask the manufacturer, the Applicant, to compare those calculations to LOFT experiments, for example.

So we do look for verification type activities where it is possible.

Now there are not that many opportunities for saying show me how your code can be demonstrated to be useful at high-burnup, okay?

CHAIRMAN JACKSON: Right.

MR. HOLAHAN: I think as mentioned earlier we are just beginning to do some experimental work to show how high-burnup might affect the fuel rod performance for LOCA activities, so the mode we tend to be in is in our review and inspection activities we are dealing with sort of the current state-of-the-art understanding.

Meanwhile, we are sort of pushing the state-of-the-art with the research program, and then when we find things that are new and different, we will go back to the industry and say this looks like a legitimate issue that needs attention -- what are you doing about this?

CHAIRMAN JACKSON: I appreciate what you are saying, but I guess I am really trying to get at a specific

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issue, which has to do with on what do we predicate a regulatory decision with respect to core reload analysis, and if, you know, what is being presented represents an extrapolation beyond where there really is data, how does that drive the regulatory decision?

MR. HOLAHAN: Well, I think in the past there have been examples like that. In fact, you have heard some examples where the original analyses were maybe based on the 35,000 megawatt days per ton and here we are allowing licensees to go to 62.

In those cases what we are using is the vendor's engineering analysis and our own judgment plus a lead test assembly program which is supposed to demonstrate that their assumptions are actually coming through in the field.

Now what we learned is that lead test assembly programs, because they tend to be conservative -- for example, we don't allow licensees to put lead test assemblies which are in fact extrapolations in some way of beyond what was done before -- we don't allow them to put those in rodded positions, okay? Well, that is sort of a prudent safety approach, but what it does is it eliminates the possibility that you get any information on the interactions of that design with a control rod in it.

So when we saw that there were a number of difficult issues with burnup, control rod problems, issues

with the reactivity tests, we basically told the fuel vendors more than a year ago that we would not approve any increases in burnup until a number of these issues had been settled.

I think that is -- the four major items I am going to cover really are things that need to be better settled before there are any other increases in burnup, but in the meantime we are in the position where there are some extrapolations from the scientific database to what is being allowed in the field.

We are continuing to watch operating experience and test data to make judgments about the safety of those conditions.

CHAIRMAN JACKSON: Okay.

COMMISSIONER McGAFFIGAN: Were you expecting to get applications for increases in burnup before that analysis was made?

MR. HOLAHAN: Yes.

COMMISSIONER McGAFFIGAN: How high were they likely to be asking you to go?

MR. HOLAHAN: Well, I don't know of any specific examples but from general discussions of what the industry is interested in, I think it would be fair to say that 65,000 megawatt days per ton and probably 70-72,000 megawatt days per ton are things that are not too far off and to a

certain extent we have slowed down the industry's move to those levels.

COMMISSIONER McGAFFIGAN: Was the intent to use that fuel in this country or to use it for export to -- how are other regulatory bodies dealing with this issue?

MR. HOLAHAN: I am not so familiar with the market for fuel in other countries. I think at levels of 65,000-70,000 megawatt days per ton that would be useful to U.S. utilities in planning for a two-year cycle.

It would give, not that it is absolutely necessary, but that it would give them additional flexibility on how to design those reloads and it would probably allow them to use some of the fuel more fully than they currently can.

COMMISSIONER McGAFFIGAN: So at that level if they want to run for two two-year cycles they could keep the fuel in, fresh fuel rod could expect to last two two-year cycles at that point?

MR. HOLAHAN: I think so, yes.

MR. KING: From industry papers I have read, the numbers Gary has quoted are about what the industry is targeting to achieve.

Overseas, France and Japan and others have set burnup limits and utilities are trying to increase those for economic reasons also and I think the numbers they are

shooting for are comparable to what the U.S. industry is shooting for.

CHAIRMAN JACKSON: Do we have actual energy deposition criteria that we use and does any of the foreign data suggest that, you know, the energy deposition criteria are violated at elevated fuel performance?

MR. HOLAHAN: Yes. I will address that directly.

CHAIRMAN JACKSON: Okay.

[Slide.]

MR. HOLAHAN: If I could have Slide 15 you will see it is the first bullet on Slide 15. This is just a summary of the four issues that I am going to cover -- clad integrity during reactivity accidents is in fact exactly the area where energy deposition tests is showing something inconsistent with what is in our regulatory standard.

I also talk about the general aspects of fuel performance with increased burnup, related topic of oxidation buildup, or cladding oxidation during normal operation and what we think needs to be done in that area, and our ongoing dealing with the incomplete rod insertion.

I think we can skip 16 and go directly to the technical issues, starting with 17.

CHAIRMAN JACKSON: Are you going to talk about current licensing basis criteria? Are you going to come back and talk about that?

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MR. HOLAHAN: I am going to talk about it in the context of each of these technical issues.

CHAIRMAN JACKSON: Okay. All right, and you are going to talk about how -- what criteria you think need to be revised?

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: Okay.

[Slide.]

MR. HOLAHAN: On Slide 17 the one -- this is the one that we know needs to be revised, and that is cladding integrity during reactivity accidents, rod ejection for the PWRs or rod dropout for the boiling water reactors.

I think Tom mentioned it in his introductory remarks. We don't consider this a significant safety issue because of the low probability of the event and limited consequences but we have seen in the data that our criteria are not sufficient to prevent damage of the fuel and so what we would like is to have good regulations based on good scientific evidence, and what we have got now is new information that shows that the criteria that are in our regulatory guidance and have been used to license many of these reactors are inconsistent with the experiments.

So we have a situation where we feel that those criteria need to be revised. Now what we see is the criteria need to be revised downward from something like 170

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calories per gram, recommended value, interim value from the Office of Research is 100 calories per gram. They have recently sent NRR a letter with that and a few other recommendations. We are in the process of dealing with that.

We have been working pretty closely with them over the last few years and the 100 calories per gram does seem like a sensible interim limit.

CHAIRMAN JACKSON: Now you say it is not a significant safety issue because of its low probability and limited consequence, so what kind of timeline are you operating on in terms of considering this recommendation from Research?

MR. HOLAHAN: I think there are a couple of aspects to it.

The recommendation relating directly to the criteria, interim 100 calories per gram, we could be able to make that decision relatively quickly.

There are some related recommendations with respect to things like inspection of the fuel and I think we need to work through that and think about the implications of what kind of inspection. I think we don't know quite so much about the implications on the operation of the reactor system and what constitutes an effective inspection program and how would it impact operation of the plant and so forth,

so we need to sort some of that out before we make a recommendation.

COMMISSIONER McGAFFIGAN: Could I ask --

CHAIRMAN JACKSON: Please.

COMMISSIONER McGAFFIGAN: What is the effect of going to 100 calories per gram on licensees, either fuel cycle or utilities? Is there fuel out there at the moment that will -- or configurations that will be affected?

MR. HOLAHAN: We don't think so.

That goes really to the fourth bullet, which is where do get the analysis that shows that the revised criteria are being met?

The industry has through its owners group done some what I would call generic calculations which show that typically both BWRs and PWRs are well below 100 calories per gram for rod ejection or rod dropout, and that is because they have gone to a more sophisticated analysis -- 3D neutronics calculations.

In addition, it reflects the fact that in PWRs for example the reactors are not run with rods in the highly inserted positions as the reactors were originally designed maybe two decades ago.

For improved fuel performance they are basically run in unrodded configurations and so there is nothing to eject really at full power and at intermediate powers it

is -- the reactivity worth available for ejection is really lower than it was assumed in the mid-'70s when most of these original calculations were done.

We are now in the position where we have some generic calculations which say our revised criteria can be met. The Staff is in the position to do some calculations to say it is reasonably comfortable with it. But we have to make a decision about whether from a regulatory point of view whether that is sufficient because what we have got on the licensee's docket is a very conservative analysis against a non-conservative criteria.

I think that makes frankly for a sloppy regulation and what we would like is through some mechanism to have the licensees, hopefully through some generic calculation so that they don't have to expend excessive resources on what we have already said is a relatively low safety significant issue, but I think it needs to somehow find its way into the FSARs and into the regulatory scheme to get appropriate analysis to show that the interim criteria are met.

I think at this stage we need to sort out what is the best regulatory approach to doing that so technically I think the plants can meet the 100 calories per gram criteria but they just haven't done the analysis to show it -- so we need to find a way to get from here to there.

That is also one of the things we are following up

on.

CHAIRMAN JACKSON: In rod insertion or ejection events, the main ones would lead to concerns with energy deposition?

MR. HOLAHAN: Those are the ones that have the potential for getting close to 100 calories per gram. I don't think there are any others.

I suspect very much that when the ATWS analyses are done because of the shape, broadened shape, of the power pulses there is more time available for the energy to disperse into the coolant, and so I suspect that -- I would say I am pretty confident that we are dealing with delimiting cases here with the rod ejection and rod dropout.

COMMISSIONER ROGERS: What about power oscillations?

MR. HOLAHAN: I think the BWR stability issues, low flow or natural circulation, I think those are very similar to what we are seeing in some of the ATWS calculations and I think the power spikes can get very high, but they don't tend to be -- the energy deposition is not as limited in time as the rod dropout or rod ejection.

In addition, we have taken a number of interim steps over the last several years so that we don't expect to see the boilers having these problems. They have got operating administrative controls in place and they are also

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putting final solutions to these problems in place, for example, reactor scram on the early oscillations to prevent the larger examples.

So I think we do have delimiting cases here.

CHAIRMAN JACKSON: Might this change with MOX fuel?

MR. HOLAHAN: I think probably there are a number of issues with MOX fuel. The one that I am going to speculate about, since we haven't studied it too well, we know that the MOX fuel is more reactive in the sense that it is -- because of the lifetimes and the prompt criticality that you can get more energetic spikes, so I think that will be an issue.

I think -- can you get greater than 100 calories per gram spike with MOX fuel? I don't know but I think there is more potential there than in the current uranium fuel.

MR. KING: Yes, I would agree with that. I think it is the neutron, the physics characteristics that really need to be looked at carefully with MOX fuel.

CHAIRMAN JACKSON: Okay, thank you.

MR. HOLAHAN: If I can go on to Slide 18.

[Slide.]

MR. HOLAHAN: In terms of fuel performance, we are talking about not just uranium fuel pellets but the whole

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fuel assembly. As I mentioned earlier, we have informed the industry that before there are additional increases, there needs to be support for changing the burnup limits. Those are in terms of test and analysis and taking research information into account.

CHAIRMAN JACKSON: Where is, again, let me make sure I understand, where is the de facto cutoff today?

MR. HOLAHAN: Well, we don't have a national value. In effect, what the staff has done in the past is to review each fuel design and to review the proposed burnup limit that goes along with that design. So when a vendor comes in and says they have identified a new XYZ type fuel assembly, they need to propose and justify the specific limit that goes along with that fuel. So there is a spectrum also.

CHAIRMAN JACKSON: What is the range?

MR. HOLAHAN: The range tends to be in the 55 to 62. I think 62 is the highest. 62 gigawatt days per metric ton uranium would be the highest, although others are 60 or below. The 50 to 60 range, I think, is typical.

We have said, stop where you are and we need to see -- we need to have the reactivity, LOCA and rod insertion type issues resolved and more information on the lead test assembly programs before we go any further.

I think one thing that is fair to say is the lead

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test assembly programs have not been entirely effective in giving us early warning of potential problems and we are looking more closely at those. There is a tradeoff here.

Lead test assembly usually means that perhaps four assemblies are put in among nearly 200 in a core and those are ones that have not been tested previously so they have some aspect of them. Either they are pushing some new material or new design. We don't normally get lead test assemblies pushed to limiting burnups because they are put in nonlimiting -- they are generally put in lower power and non-rodded positions. So the program is giving us information on the performance of these new materials and new designs but it doesn't really tell you a lot, in some cases it doesn't tell you anything about how these designs are going to perform at higher burnups.

So we need to have, in fact, a better way of getting early information on high burnups. We may need to change our view on lead test assemblies and to maybe have them used in some staggered sort of way in which they are allowed to be put into higher burnup locations because, otherwise, you are just not going to get that information.

The third bullet on here really says in the absence of anything else, operating experience is going to teach us about the performance of the fuel. This is where our information on control rod problems has come from. We

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do learn about the fuel performance from looking at fuel leakers. We do follow up on reports when there are a number of fuel problems. We take that experience back to the licensees and the vendors and have them deal with those situations.

Typically, we are seeing maybe one, maybe two fuel rods in an operating cycle which are failed for some reason and although that number is small, in fact it is very small compared to what was assumed in analysis and licensing of the plants. We do want to learn from that experience. Even if it is only one fuel rod out of 50,000 that failed, it failed for some reason and we want to understand the root cause. Is there some additional oxidation going on, is there a water chemistry problem, are there vibration problems associated with a given design?

So NRR, Research and particularly AEOD is looking at operating experience to learn from it.

CHAIRMAN JACKSON: Now, wasn't there about a year ago a licensee that had a fairly large number of leakers?

COMMISSIONER McGAFFIGAN: Calhoun.

MR. HOLAHAN: And I think Haddam Neck.

MR. CALLAN: But Fort Calhoun has particularly a particularly acute problem there.

MR. HOLAHAN: I think as you go back in time, you see the problems were more serious. I would say over the

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past several years, fuel fretting and vibration has probably been the dominant cause of failures. Ralph, you have insights into that.

MR. MEYER: No, that's correct. The only thing I could add is even these episodes of failures you have heard mentioned, the numbers are still relatively small. My recollection is that in the last four or five years the largest single episode of fuel rod failures only involved around 25 fuel rods.

CHAIRMAN JACKSON: Does that change the patterns as such that it, you know, affects energy deposition at all?

MR. MEYER: I don't think so. The big reactivity actions that we look at are very localized. The rod drop and the rod ejection, which are the only ones that take the reactor prompt critical, I mean, these are prompt critical power bursts and they just happen in the vicinity of the single rod that is ejected or dropped and I don't think the presence of a couple leaking fuel rods in that region would have any effect on this.

At operating temperatures, even leakers get dried out on the inside. The moisture from the interior of the rod is expelled so it is not present under most circumstances to participate in some energetic reaction.

MR. HOLAHAN: Probably the primary consideration is the physical condition of the cladding. If that fuel rod

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is leaking because it is heavily oxidized or because it has spalling on the surface or something, it is not going to perform well during a reactivity transient but it is probably not because it has a pin hole in it and it has been leaking; it is probably because that particular fuel rod, whatever is causing that fuel failure, is also causing it to have lost its ductility and to be more likely to fail.

We are still dealing with a relatively small number. I think it is somewhat instructive to think back to the '70s when most of these plants were licensed. We used to talk, and if you go back to the FSARs, they reference 1 percent fuel failures in a lot of the analyses. Well, 1 percent of 50,000 is 500. We never see 500 fuel rod leakers. It is rare to see five and it is not unusual for plants to shut down and remove one or two rods because it does produce radiation and contamination in the plant and it is a more efficient way to run the plant when it's clean.

CHAIRMAN JACKSON: If you look at the predicted fuel fragmentation and dispersal into the coolant, how much fuel is involved and how does that dispersal of the fuel affect reactivity?

MR. HOLAHAN: Let me answer in two parts. Historically, when we were concerned about fuel fragmentation, we were talking about very high energy inputs, 280 calories per gram. The primary issue, safety

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issue associated with that, was that energy deposition is so high that not only will it rupture the cladding but it will also have molten fuel and molten fuel dispersed into the water. That not only damage that individual rod and releases its reactivity but it can produce pressure pulses in the system.

So that was the origin of what is the fuel fragmentation concern. And I think we see -- I mean, there are no designs out there that have any energy inputs that are anywhere near 280 calories per gram.

Now, we have seen in the experiments and I think realistically we could expect at relatively low energies to see cladding rupture and fuel dispersal. I think there are cases as low as 30 calories per gram, Ralph?

MR. MEYER: Yes, 30.

MR. HOLAHAN: But I think what we are seeing in those cases is the dispersal of fuel pellets that have already been fragmented, almost powdered. And what you've got is hot, 600 -- well, I still do Fahrenheit. Ralph will correct me. What you have is hot fuel but nothing near molten fuel dispersed into the water. So we don't expect that there are pressure pulses associated with that that are a concern to the reactor coolant system or the vessel.

So at the relatively low energy that I think the experimental data suggests that you can have fragmentation,

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if you had a rod ejection and you had embrittled fuel, you could expect to get a relatively small amount of fuel because, in fact, what you see is a rupture of the rod and fuel from a given area dispersed into the coolant.

But I think that would make a very dirty primary coolant system from a reactivity point of view but it doesn't produce the pressure pulses and I think there is very little likelihood of producing any, you know, doses outside of the plant. But I think it will produce contamination problems in the plant.

CHAIRMAN JACKSON: There would be doses inside the plant. There are people inside the plant?

MR. HOLAHAN: Right. I think it would be a messy cleanup problem.

MR. MEYER: Keep in mind, though, that the interim criteria that we have suggested in this research letter precludes the failure of the cladding. We believe that the plants can meet the criterion where you can demonstrate that the cladding won't fail, it won't crack, it won't open up and so it would not let out any of these particulates.

CHAIRMAN JACKSON: At the recommended limits.

MR. HOLAHAN: At the 100 --

MR. MEYER: The 100 calorie per gram, with screening to rule out the highly spalled rods that lead to these unusually low ones like the 30 calorie.

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CHAIRMAN JACKSON: But not at the 170.

MR. KING: Yes. That is an important point. We have recommended the number change from 170 to 100 but along with that, we are recommending the intent of the criteria change. Previously, the intent of the 170 was to define the point at which cladding would rupture and you would have to consider the source term. What we are recommending is the 100 would be the point at which the cladding maintains its integrity and, because of fuel dispersal issues, we believe that ought to be, the intent of that criteria ought to be to remain below that so you don't have to worry about cladding integrity.

MR. MEYER: It is a red line, not-to-exceed limit.

MR. KING: Then you don't have to worry about the fuel dispersal issues, whether it is pressure pulse, contamination, flow blockage or whatever it is. So that may be a point that was missed before but that is part of our recommendation.

CHAIRMAN JACKSON: Okay, so that is an interesting one.

Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Could you tell me the relationship between the utilities and the fuel fabricators? Do fuel fabricators today have guarantees in their contracts? It is a competitive industry. Do they guarantee

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there will be no more than one per 50,000 and if so we pay for the cost of cleanup? What is the -- how does that work as a commercial -- I am looking for some degree of self-regulation from the industry itself in this area, so how does that work?

MR. HOLAHAN: I believe there are warranties. I don't know the details of them. The staff doesn't normally get involved in dealing with that.

MR. CALLAN: There are warranties, Commissioner, and there is a lot of litigation. There is currently litigation going on between Fort Calhoun and the vendor and I am aware of others. So it is an area that the utilities pursue through the courts.

CHAIRMAN JACKSON: Let me make sure I understand one thing. Who has the ultimate responsibility to do the core reload analysis?

MR. HOLAHAN: The licensee.

CHAIRMAN JACKSON: And that comes under Part 50?

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: 50 what?

MR. HOLAHAN: It depends on how they are doing it. For example, if they are doing it within the constraints of their existing technical specifications, I would say it is part of their license and 50.36 defined what is in their technical specifications, which frequently establish by name

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and version the codes that should be used and the criteria.

Where the licensee is using the vendor to do the analysis, the licensee is still responsible. For example, as a result of our Siemens inspection, we identified some difficulty with one of their fuel designs which is to be used in the Susquehanna reactor and we are meeting this week with the licensee to say, this is a licensee responsibility. The quality controls on that design are requirements that derive from the licensee's quality assurance program, which derives from Appendix B of the regulations.

So although we review and approve and inspect the vendors, when it comes to dealing with the responsible parties, we will go back to the licensees who are using that fuel.

CHAIRMAN JACKSON: So 50.36 or Appendix B completely bounds the universe?

MR. HOLAHAN: Well, we talked about LOCA analysis and then, of course, there is a 50.46 requirement. And probably I left something else out.

CHAIRMAN JACKSON: I am not so much trying to put you on the spot in terms of being able to give me a list but, rather, to know that for all licensees there is some aspect of the regulation that bounds them.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: It is not all in license

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conditions or just tech specs.

MR. HOLAHAN: I don't think that we have identified any issues that are not covered by the regulations.

CHAIRMAN JACKSON: Where would it be if it is not in the license itself?

MR. HOLAHAN: If it's not in the license, meaning a specific license condition, those are technical specifications, then I think it's in the general that says the plant is going to be run in accordance with the regulations. That is part of the license, and the requirements are in the regulations.

MS. CYR: I mean, are the peak cladding temperatures that are a part of 5046 in the ECCS which has the 2,200 degrees and is specified there which has a big impact on this, most of it as I understand it, and I can't speak authoritatively, is in the tech specs, and it's mostly in terms of the way their license conditions are specified that enough criteria of various kinds which bound each reload and then the analysis that they have to do -- deviate from that as they move to a new one.

MR. HOLAHAN: And there are probably some examples that are only in the FSAR and not specifically in the tech specs.

CHAIRMAN JACKSON: Okay. I mean that's actually

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what I was trying to get at, whether some of this is in parts of the licensing basis.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: That are not in the tech specs.

MR. HOLAHAN: Yes. I think we already talked about slide 19 with the research work on the LOCA criteria, and here again is as with the rod-ejection issue there's the potential need for visual inspection if the condition of fuel going into the reactor is going to play an important role in how it performs later. That may or may not be the case, but we'll deal with that as the issue is developed.

[Slide.]

MR. HOLAHAN: Slide 20 summarizes the issue of incomplete control-rod insertions. I think recently we've been dealing with Wolf Creek and South Texas and their experience. We issued a bulletin back in last year to get information from all the U.S. -- well, all the Westinghouse-designed plants. In addition I think it's fair to say that foreign reactor experience probably led the U.S. experience in this area, and both we in research and AEOD have been following that information with some of our individual discussions with those regulators in those countries, and also in some international-type meetings. And I think AEOD has additional details on that if some questions arise.

In effect what we did last year was to tell plants

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with a Westinghouse design that we wanted more information to verify that their control rods were inserting as required, and that was a bulletin that ran from I think about the spring of last year through the end of the year. It was a one-time bulletin that sort of had a deadline on it. In that period 35 tests were done. Some tests were done more than once at a given plant, so 35 tests is not exactly 35 plants. What we found is that in all cases the technical specifications were met, and those specifications are on the timing of the rod insertion. But what we also called for in the bulletin was more sensitive measures of how the control rods were behaving, early indication of potential problems. One thing that was looked at on the slide is called drag criteria, which is the amount of force necessary to pull a rod out of an inserted position. What we found is a number of cases, and I'd be a little more specific, what it refers to on the slide is nine tests, and what we actually found is there are really two areas of interest.

In the bottom of the fuel assembly, the last few inches, there's something called a dash pot, where the area is reduced intentionally to slow the rod down as it gets to its final resting position. So one would expect that to be a tighter fit than the rest of the rod, the rest of the thimble tube where the rod goes down. In fact the thimble

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tube is the more important area because the last few inches do not have much reactivity associated with them.

What we found from those 35 sets of tests was three plants which were above the drag criteria in the dash pot, and these are criteria established by Westinghouse as part of the design of the fuel assemblies. We found another six where there were unusually high values which I would say were precursors to exceeding the criteria. In the thimble tube area, that is the major part of the fuel assembly, we saw six plants that were above the criteria and another three where it was higher than expected. So these were early warnings that even though that fuel is still within the specifications and doesn't have a safety problem, we're getting early warnings that those need to be looked at.

Recently the South Texas plant, which has 14-foot core as opposed to the 12-foot cores in all the other plants, and which appears to be more susceptible to difficulties with inserting the control rods, Unit 1 did tests in January, and Unit 2 did tests in February. The Unit 1 tests were mid-cycle tests which were done at the staff's request, and they had two rods stick at six steps, which means within about 4 inches of the bottom of the fuel assembly -- that is to say, it was completely inserted except for the last about 4 inches. And two additional rods which we call no-recoil, which is to say when they reached

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the bottom of the fuel assemblies, they didn't bounce, and one thing we look for is you can tell something about the velocity that the fuel rods -- excuse me, the control rod is inserting by whether it bounces when it gets to the bottom. So these are even precursors to precursors in a sense of degraded performance. Unit 2 had four rods stuck at six steps, and one rod stuck at 12 steps. So they are continuing to see what I would say is degraded performance, and the staff is requiring the South Texas plant to do additional mid- and interim-cycle testing.

Lastly on the subject we have a followup bulletin under review. We have a date with the CRGR in the near future which will basically identify for rodded assemblies we would suggest guidelines for fuel management, additional testing and analysis, and also give the licensees the alternative to propose some other approach to dealing with this issue. So we would put out a letter asking them what they are doing in this area with some suggested guidelines that we've got.

So that's basically our plan for dealing with the ongoing issues with the combination of research activity and dealing directly with the licensees. I think in the spirit of getting a little bit back on schedule --

CHAIRMAN JACKSON: It's impossible. The meeting ended three minutes ago.

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MR. HOLAHAN: Well, not getting additionally beyond I think AEOD volunteered to skip their presentation unless you have questions on the foreign experience.

CHAIRMAN JACKSON: What are your big points?

MR. ORNSTEIN: Well, the most important point that I'd like to make is the fact that a lot of the problems that have been arising in the States have had early warnings overseas, and basically I refer to it as the cat -- you know, the canary in the mine. Some of the issues that we've seen unfolding at South Texas and Wolf Creek were presaged by events overseas. Again, there's no single one-to-one correspondence between a particular plant and its fuel and fuel management here versus the States.

However, there are important features that we're able to piece together, and as a result, we try to keep up on it and see if there are certain aspects of it that are important, like, for example, AEOD has been present in virtually all the meetings that have been held with Westinghouse folk and the people with Westinghouse plants have had problems which the Bulletin 9601 came out about. We've been continually pushing for the interrelationship between people in the States and plants overseas, and Westinghouse in turn has indeed, you know, followed and tried to be, you know, connected.

When it comes to the French fuel, we have

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different issues, but still it's an important information flow that has been very helpful in our understanding of the events.

COMMISSIONER McGAFFIGAN: Let me just ask, and this, maybe it goes back to Mr. Holahan, on graph 24 or chart 24 it talks about restrictions placed overseas, and it says U.S. guidelines presently being considered. What are our guidelines -- I think you just were referring to them -- what are our guidelines likely to say now that I have numbers in front of me from other countries? Are we likely to choose a burnup limit or require mid-cycle tests or where are we headed? If you're the one to answer it, that's fine.

MR. ORNSTEIN: Well, no, actually in the licensing, NRR indeed is the right organization. However, I want to caution you that, you know, the types of fuels that we see in some of these plants are not necessarily the same. For example, there's a French fuel that appears in the Belgian plants. They also have a similar Westinghouse fuel that is performing a little bit better, and it's not a one-to-one relationship. I think --

CHAIRMAN JACKSON: No, but even saying that, I think that there's a broader way, if I may phrase the Commissioner's question, I mean, clearly these restrictions fall into certain categories having to do with burnup, you know, drop tests, et cetera, and one could ask the question

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irrespective then of the specific numbers, whether we're moving along lines in these particular areas, and to the degree that you can give some specificity I think it would be useful.

MR. ORNSTEIN: Well, the important thing is that there's been an evolution at these foreign plants as to --

CHAIRMAN JACKSON: No, no, no, no. You're missing my point. My question is really -- Mr. Holahan.

MR. HOLAHAN: I understand, in the licensing aspects. Okay.

CHAIRMAN JACKSON: Right. That's what I'm talking about.

MR. HOLAHAN: I understand. In our draft of the bulletin supplement we have taken in fact what Westinghouse has suggested as guidelines and we're considering those or a modification of those. What we think is, at least to this point, probably not a single value of burnup limit is appropriate. When you go back and begin to understand the root cause of the problem, what it looks like is a burnup limit for 12-foot fuel and for 14-foot fuel probably ought to be different, because the 14-foot fuel assemblies are less rigid, and are more easily distorted.

In addition, fuel -- additional grid spacers, which are -- make the fuel assemblies more rigid and less capable of distorting, probably also affects the appropriate

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burnup. So what I imagine is we'll come out with a guideline or maybe three separate guidelines, or at one point we had six separate guidelines. But I think we'll probably be down around three, that says for a certain type of fuel a burnup limit of x, and for a different type of fuel, burnup limit of y and z. And I could tell you that I think right at the moment that x, y, and z are somewhere between 25 and 40. Okay? But as recently as yesterday I think the numbers changed, so -- and effectively I think this is one of those generic communications that we'll put out for public comment.

CHAIRMAN JACKSON: When are you expecting to propagate that generic communication?

MR. HOLAHAN: Let me ask if -- it's fairly close. Do we have a date with CRGR?

MS. CHATTERTON: The earliest date we would meet with CRGR is April 8.

MR. HOLAHAN: April 8.

COMMISSIONER McGAFFIGAN: Are you also thinking of mid-cycle drop tests. You've been doing it in South Texas. Would that become a generic refinement?

MR. HOLAHAN: Yes. I think what we're thinking about is an integral approach that says at certain burnups you don't need to do mid-cycle tests. At higher burnups, in fact the numbers we've been talking about are not

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necessarily absolute prohibitions, there could be some trigger that says if you're above 30,000 megawatt-days per ton, that triggers the need for an additional mid-cycle test, as opposed to an absolute prohibition for that to be a rodded position.

CHAIRMAN JACKSON: But in some sense these specific things deal with specific issues having to do with rod insertions.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: But there are a whole host of other considerations that would play into --

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: Some modification in terms of restrictions. Is that not correct?

MR. HOLAHAN: Yes, that's correct.

CHAIRMAN JACKSON: They'd be dealing with the LOCA kinds of analyses.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: These energy deposition considerations that we were talking about.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: Okay.

MR. HOLAHAN: I think we're going to turn to Dr. Paperiello.

DR. PAPERIELLO: We'll jump to slide 27.

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[Slide.]

DR. PAPERIELLO: Tom summarized the overall NMSS issues. The front end of the fuel cycle with respect to criticality for enrichments above 5 percent, and the back end of the fuel cycle for disposal or in the storage of spent fuel with high burnup. The current approvals for the fuel fabricators don't exceed 5 percent enrichment in U-235. The reason -- and of course current manufactured fuel is not above 5 percent, and if high burnup -- to achieve high burnup we'd have to go above 5 percent. Some of the -- we would have to amend the licenses. And the issues on criticality is computer codes used for criticality have been tested and benchmarked against certain critical experiments. There are a lot of critical experiments at 5 percent and lower. There are a lot above 80 percent. There are very few in between.

We don't have a well-established basis to extrapolate either. We need benchmark data at the enrichments we want to consider, or we have to build enough conservatisms into our criticality calculations to allow extrapolation. That is being worked on. We have research is looking into the availability of benchmark data, particularly overseas. We do believe the data exist. So that's one set of issues.

The issue of criticality goes across the whole

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range of both fuel-production facilities as well as packages to transport uranium oxide, to pellets and finished fuel assemblies.

[Slide.]

DR. PAPERIELLO: The other issue, if we go to slide 28, is the issues on transportation and dry storage. The two issues, and it drives a number of things, are again very similar to the NRR's issues, the radionuclide inventory, because this will determine how we do the shielding and whether shielding is adequate. The cooloff time, typically fuel is cooled for 5 years before it's put in a cast. They give rise to temperature and the long-term cladding integrity. If the cladding is running at a hotter temperature, there is the potential for creep and for oxidation. So we do not have an effort with research currently. We propose to get an effort at research, but in preparing for this meeting, it was clear that the NRR issues in this area and my issues overlap and they will be coordinated.

COMMISSIONER McGAFFIGAN: Could I ask on this chart, you say spent-fuel vendors applied for the average burnups up to 65 gigawatt-days per metric ton. That's -- we're talking in terms of what actually is in reactors 60 or 62 for peak, and therefore 40 or 45 for average batch, right, so in some sense if we've been doing -- the cask

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folks are well ahead of the industry if they've been applying at this --

DR. PAPERIELLO: Right now I'm just -- right now we have an application in, but it's not been approved. Right now our approvals range in the order of about 40.

COMMISSIONER McGAFFIGAN: They're in the forties.

Thank you.

CHAIRMAN JACKSON: Go ahead.

DR. PAPERIELLO: I'm finished.

CHAIRMAN JACKSON: That was your presentation? All right.

Who's the wrap-up.

MR. KING: I'm the wrap-up.

COMMISSIONER McGAFFIGAN: Could I -- before -- what are the implications for Yucca Mountain? I mean, of going to higher burnups in the sense -- any analyses you have to do to license a long-term storage facility.

DR. PAPERIELLO: I don't know. In fact as I was sitting here that was a question I asked myself. I will have to check. I would expect it to be the thermal issue. I think in terms of the enrichment and the effect of radionuclide composition is going to be bounded by the putting of either vitrified plutonium or high-enriched, you know, the submarine reactor cores in Yucca Mountain would certainly dominate, but the temperature issue I don't know,

but I will check. That occurred to me in this presentation.

CHAIRMAN JACKSON: Okay.

MR. KING: Let me try and wrap up in 60 seconds if we can. Slide 32 and 33 are the summary.

[Slide.]

MR. KING: The main points I wanted to come back to were one, there's a lot of activities under way to deal with the high-burnup fuel issues. They cut across a number of our criteria and they cut across the offices. We have activities and plans to deal with the in-reactor issues. We're working with NMSS to develop plans to deal with the out-of-reactor issues. The risk implications of the high-burnup fuel performance. Our work is really geared toward trying to maintain low risk from high-burnup fuel, and we feel that that can be achieved, although there's still some issues that need to be verified, particularly dealing with the new phenomena we're seeing of fuel dispersal and higher source terms and so forth. But what we're doing is we illustrate it with the criteria, trying to develop criteria that deal with those issues in a way that they don't contribute any additional risk or any new types of accidents to the plant.

In terms of concerns on slide 33 -- maybe concerns is maybe a little too strong a word -- we feel cooperation with industry is important, and it's two-way cooperation.

We've got a lot of our data from foreign sources, experimental data. A lot of the details of that are proprietary. We've been working with our foreign partners to try and get that released to industry. Our industry's very interested in that data. We've done that so far through things like having special sessions at the water reactor safety meeting, in a special issue of the Nuclear Safety Journal. We'll continue to try and get that data released.

We had a concern early on that industry was not doing any experimental work in the transient area -- they do a lot of steady-state work -- although we now have made some progress in that area, at least reached an understanding with DOE and EPRI to gain access to high-burnup fuel samples that we could use in our program at Argonne that'll be dealing with the LOCA performance.

We also made some progress in getting access to industry steady-state data. There's a program called the nuclear fuel industry research program that had been kept proprietary. We now have got an agreement from EPRI to have access to those reports.

Finally on the horizon we talked about DOE spent-fuel minimization program. There's potential MOX fuel. At this point we don't have any resources budgeted to deal with those, although in the MOX area we are trying to do some homework, and I think in the spent-fuel minimization program, it would probably be wise to think along the lines of a white paper to see what the issues are and the implications are to that.

CHAIRMAN JACKSON: Let me ask you a couple of questions. Can we go back to this issue of the current licensing basis vis-a-vis fuel design? How do we ensure that it is maintained when it is not in the tech specs?

MR. HOLAHAN: Well, in some cases it's in the FSAR, but I think we know that there are cases in which an important part of the licensing basis is only in some topical reports and the staff's review and approval of those. The staff has generated a number of recommendations based on the Maine Yankee lessons learned activity that I think we owe to the Commission this week or the end of this month, pretty close. That's a combination both of the staff's internal review of the Maine Yankee lessons learned plus the Ed Jordan's ISAT team had a number of recommendations related to the subject.

My recollection is it is about half, 11 of the 24 staff recommendations in this area go to the point of how are codes reviewed and approved and how do you make sure that it is in the licensing basis.

I think we have already started to move in that direction. But I think it is fair to say that in the past

there have been examples in which code reviews and licensees' commitment with respect to code calculations or some of these other issues we have been talking about today are in letters or topical reports and they are not captured in the FSAR. So they are lower level commitment documents.

One of the things we have identified is an activity to assure that when we review and approve things in the future that approval of the topical reports are clear, that the issues are in those reports and that when licensees use these, they get them into either license conditions or in the FSAR.

So I can't promise that is the way they were in the past. I think we know of examples where they weren't. But I think we have recognized it and are moving in the direction.

CHAIRMAN JACKSON: Given that the Commission is considering papers coming out of the Millstone lessons learned and 50.59, are the activities and the recommendations in those papers going to allow us to capture what needs to be captured relative to this issue with respect to the codes, fuel design?

MR. HOLAHAN: Yes. I would say the combination of the 50.59 Millstone and Maine Yankee lessons learned, together, definitely, I think, cover this issue.

CHAIRMAN JACKSON: How?

MR. HOLAHAN: Well, there are a series of specific recommendations which I just happened to bring with me for things like establishing standard in format guide for topical reports, for assuring that the staff's questions and responses to those are put in the approved versions of topical reports, sample applications are all --

CHAIRMAN JACKSON: These are things coming out of Maine Yankee.

MR. HOLAHAN: Yes.

CHAIRMAN JACKSON: I am saying to you, are they included in the actions that are before the Commission for the Millstone lessons learned, which is focused on the current licensing basis issues?

MR. HOLAHAN: I think they have been coordinated and both are owed to the Commission. But they are not all in one document but they are all in the staff's plans.

CHAIRMAN JACKSON: Well, that is not quite the answer to the question I am trying to understand.

MR. MIRAGLIA: Madam Chairman, in terms of capturing commitments, I think the commitment discussion in the Millstone Part Two would cover this. The specifics on the codes are more directly related to Maine Yankee but the efforts that we are doing in the captured commitments is to make sure they are reflected in appropriate places, the licensing basis, I think, would encompass that.

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CHAIRMAN JACKSON: All right.

Let me just ask a separate kind of question. Is the fuel designed to withstand the blowdown loads for a large break LOCA and how is that affected by some of the embrittlement issues and so forth that we are talking about?

MR. HOLAHAN: Well --

MR. MEYER: The answer is, yes.

MR. HOLAHAN: The answer is, yes. But most of what we have talked about is the heatup of the fuel and the LOCA concerns are not really during the blowdown.

CHAIRMAN JACKSON: That's right.

MR. HOLAHAN: And so these are really during the heatup phase.

CHAIRMAN JACKSON: Exactly.

MR. HOLAHAN: But, yes, the criteria we have for the fuel, structural integrity of the fuel assemblies and the stress and strain limits and all of that do take LOCA loads into account.

CHAIRMAN JACKSON: Are we explicitly considering that as we look at this issue of embrittlement and loss of ductility, et cetera, in the high burnup situation?

MR. MEYER: We are looking at that in the research program but I have to say that we really haven't initiated that part of the work. We identified it almost over two years ago --

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CHAIRMAN JACKSON: Is it unimportant?

MR. MEYER: No, it is not unimportant. In the deep, dark past there were generic evaluations done, not only for the blowdown load but in combination with earthquake loads and those have been documented and have -- that seemed to relieve all concern until we get to the point where we understand that the whole fuel assembly will now have less ductility and it may have lower fracture toughness and the kind of things that would come into that analysis. We do plan to review that but we have to get the mechanical properties from our measurements before we have a basis for doing that assessment.

CHAIRMAN JACKSON: Well, I am not at all talking about what has to come first. I am really specifically asking you whether or not you are considering the issue of blowdown loads or planning to revisit it as part of what you are doing?

MR. KING: Yes, we are planning to do it. We haven't gotten that far yet.

CHAIRMAN JACKSON: All right.

Commissioner Rogers?

COMMISSIONER ROGERS: I don't have any additional comments.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: No additional questions.

CHAIRMAN JACKSON: All right.

Thank you.

I would like to thank the staff for a very informative and long briefing. Long because of us. And I would urge the staff to continue its cooperation in international experiments. It seems like that is an important source of data and information for us, in order to establish failure limits for high burnup fuel and reactivity insertion accidents. But operational experience, as we have been discussing for the last two hours, clearly suggests that high burnup fuel has effects that go beyond reactivity insertion and I am going to urge you to do what you have already told us you are doing, namely to ensure that you have the appropriate research and other tools in place to address emerging issues that relate to core and fuel designs and plant operations.

You know, the agency's licensing criteria which, you know, you are expecting will hold up to a certain extent beyond the current burnups is based on 1970s experience and to burnups that were to less than 30 gigawatt days per ton. So you say you are and so I am saying that you should reassess our fuel regulatory guidelines and licensing criteria covering not only reactivity insertion accidents but the design basis accidents we have been talking about and LOCAs.

But the thing I would particularly encourage the staff to do is to continue not only gathering data and information but integrating it on as much of a real time basis as possible and to confirm that plants are safe and in compliance with their licensing bases.

The final comment is that I am taking off from what Mr. Miraglia said, that all of these various lessons learned that we have done and what the staff, the Commission has been asked to look at and approve will ensure that we capture what we need to capture in this area, vis-a-vis fuel design in the licensing basis.

So if there are no further comments, we are adjourned.

[Whereupon, at 11:50 a.m., the briefing was concluded.]