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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

AND MATERIALS (ACNW&M)

180th MEETING

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WEDNESDAY,

JUNE 20, 2007

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VOLUME II

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T-2B3, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Michael T. Ryan, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

MICHAEL T. RYAN	Chairman
ALLEN G. CROFF	Vice Chairman
JAMES H. CLARKE	Member
WILLIAM J. HINZE	Member
RUTH F. WEINER	Member

NRC STAFF PRESENT:

CHRISTOPHER BROWN

LATIF HAMDAN

JOHN FLACK

DAVE McINTYRE

BOB EISINGER

ANTONIO DIAS

DEREK WIDMAYER

NEIL M. COLEMAN

HAROLD SCOTT

ALSO PRESENT:

CHARLES FITZPATRICK, State of Nevada

I-N-D-E-X

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

(8:32 a.m.)

CHAIRMAN RYAN: The meeting will come to order.

This is the second day of the 180th meeting of the Advisory Committee on Nuclear Waste and Materials. During today's meeting, the Committee will consider the following: the NRC Office of Public Affairs' perspectives on radiation risk communication, a basic primer on high-burnup spent nuclear fuel and its cladding, ACNW staff attendance at recent technical meetings and updates related to those meetings, and discussion of ACNW letter reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Chris Brown is the Designated Federal Official for today's session.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. Should anyone wish to address the Committee, please make your wishes known to one of the Committee staff. It is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume, so they can be readily heard. It is also

requested that if you have cell phones or pagers you kindly turn them off at this time.

Without further ado, it's my pleasure to welcome David McIntyre, who is going to speak to us today on NRC's outreach on radiation. David is with the Office of Public Affairs, and, David, welcome and thank you for being with us.

MR. McINTYRE: Thank you very much, Mr. Chairman, members of the Committee. If I could start, I'd like to take note of the new name of your Committee. As a graduate of the College of William and Mary, it's gratifying for me to see my alma mater, W&M, incorporated into your acronym.

(Laughter.)

CHAIRMAN RYAN: Very good.

MR. McINTYRE: I haven't been able to see that acronym without doing a doubletake yet, so it's good to see some recognition for the old school.

CHAIRMAN RYAN: There you go.

MR. McINTYRE: But anyway, the reason your staff so graciously invited me to address you this morning is because the Commission has had on its radar recently a need that they see for the agency to improve its outreach to the public on the basic biological effects of radiation, sort of the basic

information about radiation, what it is, why we -- where it comes from, why we should or should not be concerned about various radiation sources, and I wanted to brief you about what the agency's outreach efforts are and what we've begun to do in terms of first steps to meet the Commission's concerns on this.

And first of all, I mean, that would be -- sorry, I forgot to hit the button to go to the next slide. One of the things I would like to stress is that the Office of Public Affairs is obviously a prominent part of the agency's outreach to the public, but it is by no means all of it.

Every program office has independent outreach efforts about their regulatory efforts, and as I would say, as part of the key message, any NRC outreach is about the health effects of low dose radiation exposure, because it is the agency's mission to protect people and the environment by keeping these exposures as low as reasonably achievable. So anything that relates to this subject, anything that the agency does in its public outreach.

Now, I'd like to start off --

CHAIRMAN RYAN: If I may just interrupt you for one second.

MR. McINTYRE: Sure.

CHAIRMAN RYAN: We have some participants on our bridge line, which I'd like them to introduce themselves, just to make sure all the connections are working. Will the folks on the bridge line please log in? Is there anybody on the line?

MR. McINTYRE: I put them to sleep already.

(Laughter.)

CHAIRMAN RYAN: I guess they're not on the line yet. If they sign in, we'll just take a minute and let them --

MR. McINTYRE: Okay.

MR. FITZPATRICK: Charles Fitzpatrick, State of Nevada, is on.

MR. McINTYRE: There he is.

CHAIRMAN RYAN: Hello, Charles. Good morning.

MR. FITZPATRICK: How are you?

CHAIRMAN RYAN: Fine. Thanks for being with us.

MR. FITZPATRICK: Thank you.

CHAIRMAN RYAN: Any other participants? Dr. Malsch, I understood you might be there?

(No response.)

Guess not, so we'll proceed.

MR. McINTYRE: Okay.

CHAIRMAN RYAN: Thank you again for the interruption.

MR. McINTYRE: I'd like to start just by saying a little bit about OPA and where we fit in the agency. We are part of the Commission Office staff. We're not part of the EDO staff. And we report -- my boss reports directly to the Chairman, and our task is to assist him in his statutory function as the principal spokesperson for the agency.

And we are, of course, the primary link with the news media. We're available to staff any time they get contacted directly by reporters that we can help out and facilitate getting that information to the news media. And we can sit in on interviews, or, more often, we get the inquiries and we then reach out to staff to get the information, if we don't have it on hand.

But we also do take a lot of inquiries from the public through e-mail and phone calls every day in our office over in One White Flint North, and at our regional offices, and these can range from anything from, what do I do with my tritium exit signs, to, you know, why are they dumping radioactive waste in the landfill down the road from me? Anything

like that.

And we do have regional offices that do a lot of the grunt work for Public Affairs. You'll see them at the public meetings, and you'll see my colleagues from the regions quoted a lot in the newspapers, because they're the ones handling the specific questions about the powerplants and various issues in the localities.

And we all like to see our name, so I thought I'd put that slide in. We have four here in the -- four Public Affairs officers, plus Elliot Brenner and Beth Hayden, our Director and Deputy here in Headquarters, two in each of the regions except for Region IV, where Victor Dricks handles things by himself quite capably.

This slide is just a little bit about the extent of OPA's efforts for the agency, and I've highlighted in yellow public inquiries, web video brochures and fact sheets and public meetings, because those are the three areas that I felt were more -- most salient to our topic today.

Okay. Now, I would basically sort of divide the agency's public outreach efforts on radiation to three legs of a triad as it were, one of which would be OPA. We do various fact sheets, which

I've given you in the briefing packets. These are fact sheets such as biological effects of radiation, radiation protection in the tooth fairy issue, or fact sheets we put together when -- for the tritium spills out in the Midwest, trying to put those issues into context.

They are available as handouts at public meetings. They are on the website. We also assist the program offices with their web content for their various pages. The way the agency handles the internet site is each office is responsible for the content of its area, so you don't have a unified real -- there is no central voice or authority that's really directing how the information is presented, so there can be some unevenness, but that also allows the staff to be directly involved in what information is presented there.

OPA has a special web page for students and teachers, which we'll show you later in my presentation. We assist staff at public meetings. So we're there when the staff is going out to meet with the public, we have -- generally we'll have a Public Affairs officer that can handle any media inquiries.

We take the public queries from the media and the public, and we do advance work for speeches of

the Chairman or the other Commissioners, as they request.

Now, a lot of the agency's outreach comes through the program offices, and they really do have, I feel, an impressive outreach effort in some of these offices. For instance, NRR, Nuclear Reactor Regulation, their Division of License Renewal has a very extensive outreach effort for public meetings and web content for information relating to license renewal of the powerplant.

And as you may know, they are currently busy with some very contentious license renewals. They've got on their plate at the same time Oyster Creek, Indian Point, Pilgrim, Vermont Yankee, and -- well, those are the main ones that are contentious, all up in Region I.

NRR also does annual assessment meetings that are rather sparsely attended by members of the public for the most part, but this is a chance to tell the public exactly how the licensees are performing, the powerplants are performing, and the agency's efforts to make sure that they are performing safely.

The Office of New Reactors is just beginning an outreach effort. I believe the first big meeting will be next week in South Texas, to explain

the Part 52 licensing process, so in areas where we might -- where we are expecting to receive applications for new powerplants.

And then, of course, there is the NMSS High-Level Waste Repository Safety Division has an outreach team headed by Janet Kotra that is very active out in Nevada and California and the areas around Yucca Mountain. They are out there this week to have a meeting with affected units of local government, just to explain how we're getting ready for an application, should it come in next year as we're told to expect.

And a lot of that, of course, is outreach to the Native American tribal nations, and the agency's outreach to those communities and those stakeholders extends beyond high-level waste. The Uranium Recovery Branch in FSME -- I'm not even going to try to say that whole name -- deals with a lot of Native American communities in the uranium recovery areas, and, of course, as you know, that industry is beginning to see a renaissance as well.

And even in the OEDO level, Marty Virgilio's title has been expanded to include tribal -- his position as the agency's main contact to the tribal communities. And, of course, we have agency

outreach to other intergovernmental organizations in dealing with radiation issues that's more of a high-level area than we're really talking about today.

And I added "etcetera" to the slide, because I'm sure I'm leaving something out, and I didn't want to offend anybody.

And the third outreach effort that I would point out is agency-wide communications effort that has come up in the last four or five years. We've had the branding initiative, which is the new agency logo, which you see here on the screen, and our marketing or branding tag line, "Protecting People and the Environment."

And in OPA, of course, we kind of fancy ourselves as the champions of plain English. When you think about it, protecting people and the environment has taken the agency's mission statement from 30 words and put it pretty succinctly into five. So that's a pretty effective, I think -- pretty effective way of communicating our basic message.

Now, I'd like to talk about some recent initiatives. We've -- I have at the end of my presentation a little bit of a demo of the agency website. But in response to Commissioner statements, both in periodic meetings with senior management and

in public briefings that the agency needs to do more to have information available to the public on basic radiation, we've added radiation protection as a key topic to the web page.

So that means when you go to www.nrc.gov, there's a box there on the right of key topics, and there is now a link to radiation protection, which gathers all the information that we already had on the website and puts it in one convenient page. So it's basically taking the information we had, bringing it together, and putting it closer to the surface. And, hopefully, that will make it easier for somebody to find if they -- if they come to our website looking for information about radiation.

In addition, Public Affairs and FSME have begun looking at this web content to see how we can improve and especially simplify the presentation of information on radiation protection. So that is an effort that will probably be quite extensive, and you'll hopefully see some improvements as time goes on and we are able to make changes to the information that's there on the web.

Now, what do we have already? On the web we have the pamphlets and brochures. And most salient to our discussion, we have this pamphlet, the glossy

pamphlet, "Radiation Protection and the NRC." I believe there are copies here in the room that people can have with lots of nifty graphics. We're actually trying to get into the 20th century on the presentation of our information.

And this is available on the web. We have a fact sheet with -- on the biological effects of radiation, which tries to put some of this in context, that radiation is all around us. You get a few more millirems if you live in the mountains in Colorado than you do if you live down here in -- along the coast. You get a few millirems if you take a cross-country or trans-oceanic airline flight, things like that.

We also have -- it's kind of hard to find, and we need to make it a little more accessible -- a personal dose calculator. It's a table that you can fill out, "Oh, yes, I've taken five airplane trips, so X number of millirems," and add that to the average background, and just try to get an estimate of your annual dose. And just to, you know, try to put things in context that way.

Now, I'd like to talk about public perceptions of radiation and what we're coming up against when we try to explain this and put it in

context. The public's main perception of radiation is danger. When you see the trefoil sign, or the new -- the red warning sign that got a lot of press before anybody realized that most people are never going to see it, it's basically, you see this, you're in danger, get out of here.

Most people's idea of radiation is probably going to the doctors and having an X-ray. Well, the doctor puts a lead apron on you and then runs out of the room to throw the switch. That's emphasizing the risk there of radiation. So I think that's what the public perception is.

So when we're trying to counter that, we have the message -- and this quote is from this pamphlet here -- that radiation can be either beneficial or harmful, depending on its use and control, the idea being that, yes, there is a risk, but if it is managed, if it is well regulated, radiation can be used safely for beneficial purposes. And that is the message that we have in just about any publication that the agency puts out about its activities.

Now, that is a simplification of NRC's official policy, which is the linear non-threshold theory of radiation exposure, but there is no

radiation dose that does not carry some measure of risk. That is not inconsistent with the previous message, but that is -- the previous message is not really what the public hears when you express the linear non-threshold theory.

In plain English, that theory becomes there is no such thing as a safe dose of radiation. And in even plainer English, all radiation is harmful.

Now, I went to the website of the Nuclear Information Resource Service, one of our frequent interloculers on a variety of issues, and I found some quotes on this subject that take that non-threshold theory. One is there is no safe level of exposure, and there is no dose of ionizing radiation so low that the risk of a malignancy is zero, and that's attributed to Dr. Karl Morgan, the Father of Health Physics.

So here is the Father of Health Physics waving a red flag about radiation. And I read that, I don't want to go outside in the sun. But they also have a fact sheet on radiation on their website at NIRS that has this quote, "Ionizing radiation travels through our living tissue with much more energy than either natural, chemical, or biological functions. This extra energy tears mercilessly at the very fabric

of what makes us recognizably human -- our genetic material."

Ionizing radiation tears mercilessly at the very fabric of what makes us human. This goes way beyond the radioactive spider giving Peter Parker his super powers. This is scary stuff. And I really think that when we go out there, and we're trying to say, "Okay, yes, there's a tritium spill at the plant near you, but it's well within regulatory limits," what we're up against is this fear of radiation. So that's what complicates our efforts to simply this message and put this issue into context.

Okay. Now, if we could switch over to the -- wow, you're good. Now, because of the setup, I'm going to have to direct Michelle on where to click, but we did rehearse this, so we can try it.

Over here on the right is the key topics box with the radiation protection key topic that I mentioned. And key topics is actually sort of prime territory on our home page. There are three people in the agency called the Web Access Group, or the WAG -- of course, have to have an acronym. One is a representative of OPA, Beth Hayden. Another is the Office of Information Service, and the other is the OEDO Communications Center. And these three have to

agree on a change to key topics.

So this is not something that changes easily or often. It really needs to be an issue of prominence to be put there.

And, Michelle, if you could -- actually, yes, click on that, please. This is the page we put together within the last month after Commissioners McGaffigan and Merrifield spoke out at the AARM briefing in May about the need to have more information on the website. Their goal is that they would like the NRC's website to be the website of choice for members of the public who are interested in finding information about radiation.

And that could be a problem -- or difficult, I should say. If you Google "radiation," the NRC first comes up at about 95 I think. If you Google "nuclear," we're there on the front. But anyway, so this page has information -- basic information, what is radiation, what are its sources, how does it affect the public, and if you scroll down a little bit, Michelle, we have links to these fact sheets and brochures that I was telling you about, and other organizations, the EPA website, our students page, and the IS -- what, yes, the Interagency Steering Committee. Sorry, I lost it there for a

second.

And this is all easily linked to now. And before, you kind of had to go searching for it. So in order to respond to the Commissioner's wishes, we put this up more prominently.

Now, Michelle, if you could go back to the home page, please. The fact sheets are also available under News and Information. If you could just hold the cursor over that button there on the left, please, Michelle. Do you see the drop-down menu, Fact Sheets and Brochures right there? And that goes to all our fact sheets and brochures, not just the ones that are directly related to this subject.

And, sorry, I threw you a loop. Now, if you could click on the Students and Teachers, this was a page we set up in OPA a few years ago, basically to try to give basic information and some suggested course activities for teachers who are trying to teach about nuclear issues. And if you click on the radiation button up here -- we'll just skip to that -- this page has some basic information, and you can scroll down, please, Michelle.

And most interesting it has a link to EPA's Radtown, USA, which Commissioner McGaffigan has mentioned a couple of times in public meetings. It's

a pretty nifty site. EPA has done a really good job in putting information about the various isotopes and where radiation comes up in our lives and industry and medicine and in nature, and put it together on an interactive site.

So I'll end by asking Michelle to click on that and show you that. And can you enlarge that? You can click on anything in this animation here, and it will go to a fact sheet. Clicking on the train gets you radioactive materials transported by freight train. Yes, click wherever you want. It's fine.

(Laughter.)

You can get the cosmic radiation during flights. Clicking on the factory over there, I think it's you -- the factory with the wrecking ball, discarded tritium exit signs. I get four or five calls a month, "What do I do with my tritium exit signs?" So I need to print out that page. But, anyway, this is a pretty nifty site that they have.

That concludes my presentation. Obviously, as I said, we're in the beginning stages of trying to improve our presentation of this information on the web and elsewhere. So I would be happy to try to address any questions you have, and certainly any suggestions you might have on how we can undertake

this task.

Thank you.

CHAIRMAN RYAN: Dave, that sounds like some great steps you've taken over the short-term history there. That's great.

One thing that strikes me -- that this seems to be NRC's effort to reach people on an individual basis, that might want to come to the website or they're interacting on one particular topic here or another.

Is there -- in that sense, it's proactive in that, you know, you have an offering to the public. It's maybe a little bit reactive when they're dealing with a particular issue or calls that come in. Is there a program to address, you know, education? Or, you know, I know that Health Physics Society has a teacher workshop program based on the South Texas chapter. And they will for free go to any school, provide information to the science teachers, packets for training and class, and if you give teachers curriculum materials that, you know, you are welcome, come on in.

MR. McINTYRE: Right.

CHAIRMAN RYAN: So is there any effort to have those either teacher outreach or other kinds of

outreach where the agency is seeking the opportunity to provide this information?

MR. McINTYRE: At this point, I don't believe there is any coordinated effort in that way. A lot of staff members do make presentations at their kids' schools, for instance --

CHAIRMAN RYAN: Sure.

MR. McINTYRE: -- and we have some materials that they can use to -- you know, visual aids that they can borrow. And we have, of course, the student/teachers web page that I just showed you. But as far as actually going out and engaging, I don't think we have dedicated any specific resources to that, at least in the few years I've been with the agency.

CHAIRMAN RYAN: Well, there's quite a large number of teachers that have gone through that program with the Health Physics Society over the years. I'd be curious -- I haven't asked them, but it would be interesting to see what their view of that effort has been.

I mean, do they see significant or permanent changes in curricula for grammar school and high school? You know, what's that doing? Because that sort of multiplies your effort here of actually

getting people to deliver the materials after they've been trained, what the information is.

MR. McINTYRE: Sure.

CHAIRMAN RYAN: The other question I had about outreach -- how do you -- I noticed on the website there's a lot of the Health Physics Society's position papers, for one.

MR. McINTYRE: Yes.

CHAIRMAN RYAN: How do you interface with licensees' programs? I mean, I know most utility companies have very substantial public affairs and outreach programs on educational issues, not just, you know, what their company does. Do you interface or interact or -- with any of that or --

MR. McINTYRE: Well, I think probably our regional offices would do most of that outreach. For instance, I know at Region I, when they have any meetings on Indian Point, they make sure that they have a health physicist along to explain any radiation issues that come up or even on a conference call with local government officials.

And Region III, of course, has done -- had to do -- again, this is a bit reactive to -- with the Braidwood tritium, had some very contentious public meetings out there last year when -- trying to explain

the leaks that had been -- you know, not been discovered for a while and putting them into context with people who were quite upset about it, understandably so.

As far as any sort of regular outreach or contact with the licensees, with the power utilities, I'm not aware of any at this point.

CHAIRMAN RYAN: It just strikes me as a thought that that might not be a bad thing. At least you can learn what questions they are being asked, and what issues are important in their programs that, you know, are coming to them. It's not that, you know, you would rely on them to represent the agency. Obviously, that wouldn't be correct.

But just communicating with them about, you know, what are people asking you, and what are the issues that you are hearing, might not be a bad thing to survey. I mean, in the radioactive waste management area, that has also been an issue over time.

MR. McINTYRE: Sure.

CHAIRMAN RYAN: So, you know, and I know that companies that are involved there do have fairly substantial public outreach efforts.

MR. McINTYRE: Right. I know that my

regional colleagues deal quite regularly with their counterparts at -- the Public Affairs spokespeople for the utility. So I can certainly ask them if they have any sort of contact like that.

CHAIRMAN RYAN: Yes. And, again, I think, you know, if it's not routine and regular, that might be an opportunity for, you know, information gathering about what's of interest to the public, and then also providing, you know, contacts and information from the agency that could be used to go forward.

MR. McINTYRE: Okay. Thank you.

CHAIRMAN RYAN: Thank you.

Professor Hinze?

MEMBER HINZE: Well, I was curious. The new security emphasis, has this in any way deterred visitations to the nuclear powerplants or other nuclear facilities by the public? Because it --

MR. McINTYRE: Dramatically.

MEMBER HINZE: It seems to me that that's just a real excellent way, and I know that in discussing this with friends that they've stopped at Big Rock Point or whatever, and, you know, very much enjoyed and understand a lot better as a result of these visits. It's much better than --

MR. McINTYRE: Reading a pamphlet, yes.

MEMBER HINZE: Right. And it's something you can take the children to. Does the NRC have any impact upon -- on this? And what's being done to maintain some semblance of public participation?

MR. McINTYRE: The security situation after 9/11 -- basically, I think all the plants canceled any public tours. And we have, when the question comes in to OPA, "Can I take a tour of Calvert Cliffs?" from a member of the public, we refer them to the utility. It's really up to the utilities at this point.

I don't have specific information. I believe a few of them have at least made some talk of reopening their visitors' centers. I know I visited the one at North Anna a couple of years ago and was very impressed with the information they had there, and I had the room all to myself at the time. So it would have been nice to have shared it with a class or a crowd of people that were interested in it.

MEMBER HINZE: Well, are they building facilities outside the secure area that would in effect provide the opportunity to transmit this information?

MR. McINTYRE: I don't know.

MEMBER HINZE: Thank you.

CHAIRMAN RYAN: Allen?

VICE CHAIRMAN CROFF: I've gone through a couple of times this booklet "Effective Risk Communication," which I think is very well done. How is the NRC staff exposed to the -- to this booklet or the contents of this? It seems to be a very useful component of, I hope, other training. Are they routinely exposed?

MR. McINTYRE: Well, I believe so. When I went to Distribution last week and requested these copies to give you, I got the last packet. And they said, "Wow, there has been a rush on this booklet recently."

(Laughter.)

So, and then, somebody told me that the Commission actually mentioned that booklet in an SRM, so every staff member went out and -- or every, you know, office ended up distributing it again. So it is there. People are periodically reminded about it, to read it and use it in public meetings, and, of course, it is on the website.

VICE CHAIRMAN CROFF: I guess I'm unfamiliar with NRC training. When a new employee comes in, is there some standard orientation they go through for a day or so on everything from payroll to

maybe this kind of stuff, or --

MR. McINTYRE: I'm not sure. On the first day, you get risk communication, but there is training available for this, and I know there's media training available and there -- we have a contractor who does dry runs for public meetings, which I've sat in on a few times and it's very helpful.

And she is really good about, you know, just stopping somebody in the -- you know, halfway through the first sentence of practicing a presentation and saying, "You just scared me," and making sure that the staff is alert to how the way we talk resonates with the public.

VICE CHAIRMAN CROFF: But at this point, the staff sort of has to know they need it, or seek it out if you will.

MR. McINTYRE: As far as I know, yes.

VICE CHAIRMAN CROFF: Okay. Thanks.

CHAIRMAN RYAN: Or has a vision that tells them they must do it, I guess. That could be something the supervisors work out for their job titles and --

MR. McINTYRE: Yes.

CHAIRMAN RYAN: -- all of that.

MR. McINTYRE: Yes, right.

VICE CHAIRMAN CROFF: Okay. No.

CHAIRMAN RYAN: One other question that kicks in my mind, if I may -- go ahead, Ruth. I'll wait.

MEMBER WEINER: No, that's fine. Go ahead.

CHAIRMAN RYAN: No, no.

MEMBER WEINER: I'm burning to ask a few questions.

CHAIRMAN RYAN: I could tell.

(Laughter.)

MEMBER WEINER: On page 3 of your booklet, you have a -- of this booklet, and I have to say this is a very thorough --

MR. McINTYRE: I can't claim credit for this. This is, I believe, the Office of Research.

CHAIRMAN RYAN: It's NUREG-0308, for those folks that don't know what "this booklet" refers to.

CHAIRMAN RYAN: I'm sorry. It's titled "Effective Risk Communication." On page 3, there is a little chart that -- of steps to implement communication, and the last step is evaluate and improve.

And I would like to know how your office or anybody associated with public communication

evaluates what you consider success in public communication, how do you evaluate it, and what do you do -- and basically, other metrics. Any comment? And they'd have to be qualitative metrics.

MR. McINTYRE: Well, in OPA, our most immediate measure, of course, would be press coverage of an issue, and whether it reflects well on the agency or our perspective. And we can be proactive or reactive, depending on the case, whether we know something is about to happen or whether we're caught by surprise on something.

As far as something in this context, I -- it is not necessarily OPA but the program offices, when they go out and do public meetings, frequently will do a lessons learned meeting afterwards and discuss, okay, remember that point of the meeting where it got a little difficult and we had trouble explaining something. And that way we can, you know, try to make sure that the presentations are better the next time.

As far as success, there is a feedback sheet that is routinely distributed at public meetings, so people can give comments like -- good or bad. And we look at those, or the program offices look at those. And it can be anecdotal, whether

people come up to us -- I mean, we have some where -- sometimes where people come up to us and say, "You know, I was really suspicious, but I -- thanks for coming. I understand a little bit more now," and other meetings where they just, you know, aren't going to believe us one way or the other.

So I don't know if that particularly addresses your question.

MEMBER WEINER: It does, and thank you. It seems to me your evaluation program is basically presentation by presentation. It is based on the particular presentation or the particular audience or the particular situation. And I wondered whether you had any look, and apparently you don't, on your public information program as a whole, as a national whole, has -- over the years, has it -- have you evaluated any major change in people's attitudes? Have you even tried to do that?

MR. McINTYRE: Yes. There was -- I don't have the information with me, but there was an effort that stemmed from Commissioner Merrifield's communications task force of a few years ago that -- I believe it stemmed from the task force, but there was -- the EDO Communications Council did a -- some focus groups around the country to get public views

about the agency, our regulatory activities, and about the information that we present.

One of them was, "Can't find anything on the website." But -- so we're responding to that and trying to make things easier to find on the website. But there has been an effort like that, and it's -- I believe Mindy Landau is in charge of that in the EDO's office, and she would have more information on that.

MEMBER WEINER: I would encourage you to continue that effort and to look rather than at things like "can't find anything on the website," to try to get your focus groups to give you some idea of the -- any basic change in attitude that your public information has produced. I'd just encourage you to do that.

Second question is: do you -- does your office or anybody associated with public information keep up with the current sociological literature in that area, and with the current health physics literature, like the report by the French Academy of Sciences, and use that to feed into your public information.

MR. McINTYRE: Well, I believe the Office of Research and the health physicists within the agency do keep up with that literature. The second

part of your question is whether that filters down to what we are presenting to the public is something that -- it does at some points, but I wouldn't say that there's necessarily a specific channel for that.

MEMBER WEINER: Well, again, I would encourage you to do that, because there have been some recent sociological studies -- and I'd be glad to refer you to them -- that look nationally at public attitudes toward nuclear power, toward things like this, and there are some very interesting results.

Finally, I think your fact sheets are really good. Let me just say that right off the bat.

MR. McINTYRE: Thank you.

MEMBER WEINER: A couple of questions I have. I was looking at your response to the tooth fairy issue. You don't address it directly. I mean, you are saying, yes, you know, that you -- NRC does this, and we get a little bit of effluent, and so on. But you don't just plain say -- you don't give an evaluation of the tooth fairy -- the whole tooth fairy thing.

And I think you would be well advised to do so. You're going to step on some toes, but the public doesn't put two and two together as a rule. You're talking -- all your public information stuff

indicates that the public will -- doesn't put two and two together, and may not realize that this is an argument against the tooth fairy project. They simply may not realize it.

And I would encourage you to be more direct, even if you think it's going to -- it is certainly going to offend whoever that actor is who started that whole tooth fairy project, but it -- if you're going to communicate, you really need to be very direct.

I also note that -- and this is very common in public information -- strontium may be in its pure elemental state, a silvery white alkaline earth metal, but it's going to show up in the environment as a compound strontium chloride or something like that.

CHAIRMAN RYAN: And it's going to be invisible, because it's so small.

MEMBER WEINER: And it's going to be invisible.

CHAIRMAN RYAN: It won't be seen by the naked eye.

MEMBER WEINER: That's right. And the final -- my final point is there is a whole segment of the population that reacts negatively to something

being manmade. Women make them, too. And I would encourage you to use the word "anthropogenic," even if it has a number of syllables, or to find an -- "people-made" is awkward.

MR. McINTYRE: Yes.

MEMBER WEINER: But "manmade" really -- let me tell you, there are people who find that -- it's off-putting.

MR. McINTYRE: Okay.

MEMBER WEINER: And I'd do that. That's all. Thank you.

CHAIRMAN RYAN: Dr. Clarke?

MR. McINTYRE: You're welcome.

MEMBER CLARKE: Thank you. I want to agree with Ruth and the others. I think you're putting out some really nice stuff and some really good information. On the subject of outreach, and other -- what other people are doing that you probably are aware of, but let me just throw out some things.

The National Library of Medicine publishes the whole toxmat series of databases. They are getting interested in radionuclides, and they are starting to put out information on radionuclides. They have an animation called Toxtown, which is very similar to Radtown, which takes chemicals that one

encounters in different settings and then gives you information about them. It's -- from what I can see of Radtown, they are very similar, and both are very well done.

But, you know, there may be merit to checking some of these other groups that are putting out information about health effects and seeing what they're saying as well.

On the subject of, how do we know that we're -- that we're being persuasive, that we're informing people that they're getting the message, I was wondering if you work with any outside firms that work with marketing and advertising, with people spending millions of dollars on commercials and knowing right away when to pull them and when to keep them running -- you know, whatever tools they use to see if their message is being effective.

There may be some other things out there that --

MR. McINTYRE: I am not aware that the agency has devoted any resources to that, in recent years at least.

MEMBER CLARKE: As I listened to the things you were doing that I thought were very good, it struck me that on a national level where people are

spending huge sums of money trying to persuade others that their message is a good one, there may be some other ways of getting that information.

Finally, on a chemical site back in a former life in Massachusetts we were involved in a large risk assessment and cleanup of a manufacturing facility that got PCBs all over the place. And it was a very brave corporation. One of the things they decided to do was test all of the former employees, to see what the blood levels of PCBs were.

Now, they're not a direct indication of risk, but they do give you an indication of exposure. But before they did that, they rounded up all of the physicians in the area and they gave -- knowing that when people heard about this they would go to their family doctor, and gave them, you know, like a one-day tutorial on what are PCBs, you know, what do they do, brought in toxicologists, brought in other doctors, brought in the EPA, things like that.

So I just kind of throw that out. If you're on a site that's -- on a hot site, or getting into a hot site, there may be some other kinds of outreach that might be valuable. I wondered what your connection with the health professionals is, if you have an active connection with those groups or not.

MR. McINTYRE: I haven't personally, and I don't know that Public Affairs has. There might be some contact elsewhere in the agency, but that hasn't reached Public Affairs at this point.

MEMBER CLARKE: Well, it's another group that needs to get the right message.

MR. McINTYRE: Definitely.

MEMBER CLARKE: Thank you.

CHAIRMAN RYAN: There are lots of resources. For example, on the physician question there's REACTs in Oak Ridge. For decades they have trained physicians in radiation emergency response, for one, and basic, you know, radiological contamination/control countermeasures in the hospital setting, and all those kind of things.

As you well know, medical licensees have health physicists, and they typically deal with that. But the physicians are the folks that people go to when they're sick and ask questions about radiation. There have been some cases where a head cold, you know, at a physician's office, "Well, where do you work?" "Well, I work with radioactive material, blew the whistle that there might be a problem with radiation." Sometimes the answer is yes, sometimes the answer is no.

So it's one segment of, what's the outreach that the agency is thinking about or doing or might do to reach various subgroups of the population that might run into these questions, like physicians or nurses or emergency room doctors, or things like that? Not necessarily for anything other than they are often the sources of this information.

You know, I mean, how many times have you been in a dentist's office and you ask the X-ray technician, "How much radiation exposure am I getting from this X-ray?" and the answer is, "Oh, it's just like a sunny day at the beach." I can't tell you how many times that has happened, because I ask every time.

(Laughter.)

And I get back information, so -- and, you know, somewhere in their training I'm sure they were told. But the proactive part of it is something to think about. If you get good information out there when it's not related to a potentially contentious issue, that's information that might come back in a good way later on when there is contention -- hitting the schools and teachers and others, as well as just general information on "here is what radiation is all about" might be something to think about. That's sort

of one that kind of takes off from Dr. Clarke's comment.

MEMBER CLARKE: If I could follow up on that, Mike.

CHAIRMAN RYAN: Well, let me finish, if I may.

MEMBER CLARKE: Okay.

CHAIRMAN RYAN: The second part is -- well, go ahead, Jim. I'm going to change topics, so if you want to finish up on that.

MEMBER CLARKE: I was just going to say that one of the things I had on my list and I forgot to ask you about is I teach in a university, and so I get students coming in and out of, you know, high school, secondary schools. And they come in with various ideas about radiation, and we do our best to give them good information about radiation.

But is there an outreach program that takes it down into the lower grades of education where people start to form their ideas and their opinions?

MR. McINTYRE: Not that we have.

MEMBER CLARKE: Again, I think the way to do it would be through the teachers, again, because you're just trying to get them the best information. And we found on the PCB project that when people are

concerned about their health they call up their doctor.

So, you know, what does their doctor tell them? You know, so that -- Mike has reinforced, I think, that would be another group that you might want to target, just to make sure they are getting good information and they have good answers for these kinds of questions. So I just wanted to ask about the identification of cases --

CHAIRMAN RYAN: Again, just to emphasize, back in a former life when I was a licensee, we sent every physician in the area to REACTs. Every one. So when they got questions, they knew what the answers were. That's not training they get in routine medical training.

MEMBER WEINER: May I make another comment?

CHAIRMAN RYAN: Let me just finish my other question, if I may.

MEMBER WEINER: Sure.

CHAIRMAN RYAN: In a different kind of vein, how do you deal with emerging information? I'm thinking currently of two things. One is, we had -- this Committee had the French Academy of Sciences members come over and discuss their report. They very

clearly see a threshold in their analysis of epidemiologic data.

The BIER Committee did not rule it out or in. I can't quote it exactly, because it's a very long, carefully constructed sentence that says it's equivocal at this point. So the issue of threshold or LNT is certainly one that's on the radar screen.

Now, I think you could think about, how do you deal with these emerging issues? Because one thing that troubles me often when I hear that discussion is what Dr. LeGuen talked about in his presentation of the French Academy report when he said, "If you want to use LNT as an administrative control decisionmaking tool, fabulous, go for it. Now, let's put that aside and talk about basic science data." Those are two different things.

You can use one as a tool, and very often we are miscommunicating about the fact that we use an administrative control tool, and we don't get that second part across very often. It is taken as the fact when, in fact, it's an assumption for the purpose of conservatism and regulatory standard-setting.

MR. McINTYRE: Right.

CHAIRMAN RYAN: So that's the phrase that gets lost. How do we start, or what efforts would you

suspect we could use to maybe combat some of that misinformation?

MR. McINTYRE: Well, I think that message is in one of the materials. I won't search for it now, but --

CHAIRMAN RYAN: And I agree with that.

MR. McINTYRE: -- either the pamphlet or the fact sheet that we -- explains the no threshold, and says that there is some scientific debate about it. But the NRC, in order to be conservative and protective of the public, uses that as its benchmark. Then, it becomes official policy and it gets translated into plain English, as there is no such thing as a safe dose.

CHAIRMAN RYAN: But that's where I think the step goes wrong, because that's not a translation. That's a mistranslation.

MR. McINTYRE: Well, that's how it resonates outside. That's not what we say.

CHAIRMAN RYAN: Right.

MR. McINTYRE: That's not how we say it, but that's how intervenors and --

CHAIRMAN RYAN: And I guess I'm just thinking out loud with you, but how do you combat that mistranslation problem? Because it's not only a

radiation question. A lot of things get mistranslated

MR. McINTYRE: Sure. Well, when we see it, we try to correct it. If it's in a public meeting with discourse, we would say, you know, actually interrupt or at the first opportunity say, "Well, that was a misrepresentation of our position or of the facts," and try to correct it.

Now, if it's in the media, we try to -- we're very active in what we call pushback, in trying to correct errors that get into the media, because even if it's minor, reporters being human will draw on their own stories for future reports or other stories that they've seen in other media for future reports.

And if it's not corrected or even if it is corrected, once it's out there, it can still be picked up and the error repeated. But no, it -- my point in the presentation was that that translation, as it were, that there's no such thing as a safe dose, is how it gets tossed back to us.

You know, but you say there's no such thing as a safe dose, and we say, "Well, no. What we say is linear non-threshold and there's an element of risk," and it gets lost in there. But our efforts to communicate that, we can communicate it as much as we can and we do, to try to correct it.

CHAIRMAN RYAN: How about the idea that we say something real simple like, "We believe our standards are safe"?

MR. McINTYRE: As a Public Affairs officer, I love that statement. I can't disagree with you.

CHAIRMAN RYAN: That's my own personal view, and one as a health physicist. I believe the standards are safe, particularly when you look at emerging information on medical exposure that, you know -- and we have medical exposures now that are higher than they've been and individual procedures that are hundreds of thousands of times higher than background that are routinely applied every day.

You know, simple examples like how many CAT scanners operating for three months does it take to equal the population dose from TMI? The answer is one. So, I mean, that's -- I guess what I'm reaching for is, how do you translate, you know, what can be -- what I refer often to as, you know, the Klingon of radiation protection. It's just very confusing jargon and it's hard for members of the public that aren't technically trained to grasp all that as it flies by and give some good examples that help communicate. We do --

CHAIRMAN RYAN: That's a tough job, I know.

MR. McINTYRE: It is, and we do make efforts in these materials and in public presentations to put radiation levels in some sort of context like this. Well, this is equal to a chest X-ray or a flight across the country. The danger there, of course, is that if you're talking about something that shows up in somebody's groundwater, they are more angry about that than they are about going to the doctor and getting a chest X-ray which they do voluntarily for -- because of the benefit for it.

So there is -- you know, that's a warning in using those, but that's depending on the situation, of course.

CHAIRMAN RYAN: Sure. Yes, absolutely.

MR. McINTYRE: Using those analogies.

CHAIRMAN RYAN: I appreciate that.

Let's see. Do you have another question?

MEMBER WEINER: One more. And this is on another topic. Like Dr. Clarke, I teach a class in the Department of Nuclear Engineering at the University of Michigan. And what I observe with my students -- and they bring this to me -- is a gulf, a growing gulf, between the students in engineering and

physical science and the students in other disciplines, which has led to -- and, by the way, you have hired several of my students in recent -- in the last three years.

CHAIRMAN RYAN: So what's the question?

MEMBER WEINER: The question is: how can we help these new employees to narrow and bridge this gulf? Because what my students come away with, and I'll quote one of them to you, is they say, "Most people are stupid. If we really want to say -- want to change people's minds, we have to get it on Oprah." Well, we're not going to get it on Oprah, and most people aren't stupid.

But this is part of that growing gulf, so without -- it's a difficult question, but I would encourage you with the new employees who come from this area to take this into account, recognize that it's not their fault, but it -- it creates a new breed of brand-new scientists who are already sensitized to the fact that people who are not scientists seem to see things wrong.

CHAIRMAN RYAN: Okay. Latif, have you got a question?

DR. HAMDAN: Yes. I think the reason we have problems is that the emphasis is on the wrong

subject. Look at your slides 14 through 20. The subject is radiation, public perception of radiation. Radiation can be either beneficial or harmful.

The Linear-Non Threshold Theory of Radiation Exposure translated -- there is no such thing as safe -- a safe dose of radiation. In even plainer English, all radiation is harmful.

NRC is in agreement. The emphasis should be on how NRC regulates the use of nuclear material.

MR. McINTYRE: Well, that is our emphasis.

DR. HAMDAN: But it's not anywhere here. What I'm saying is the framework, how will you frame things? I'll tell you the non-threshold theory, if I was emphasizing NRC regulation of nuclear theory, I would have translated the LNT to say we mean business.

NRC regulations assume -- assume that there will be no duration of even small radiation levels. That is the message -- a more positive message. This public -- in my opinion, this public communication subject is a very, very, very important subject. And I don't think -- I don't think it's done to the detail when people start going to meetings and, you know, bring speakers and all this, but the concepts need to be rethought.

And instead of emphasizing radiation,

which is a large subject and it could confuse everybody, the emphasis for regulating it, and DOE can do that, and EPA can do that radiation, and they can -- and there are books on that, and then, frankly, DOE and EPA should be doing that.

For NRC, it has this unique rule of, okay, we recognize radiation for what it is, and it is there for --

CHAIRMAN RYAN: What's the question, Latif?

DR. HAMDAN: The question is: why don't you emphasize how NRC goes about regulating? And make that not only 50 percent real message to public, make it 80 percent. And in --

CHAIRMAN RYAN: Let me help you, Latif.

DR. HAMDAN: Yes.

CHAIRMAN RYAN: I think sometimes people perceive the technical discussion as one where the emphasis is on defining risk as opposed to more of a message where -- describing how we assure safety. You know, for example, pick a number. The drinking water standard by the EPA for tritium allows 20,000 picocuries per liter of tritium in groundwater.

You could just say that and say 20,000? That's a big number. Or you could say the EPA

drinking water standard is set to assure that drinking water is safe. It's exactly the same message, but it's said two different ways.

I think your point is that you are -- tell me if I'm wrong, Latif, but I took away from your comment that focusing on emphasizing safety as opposed to defining risk might be the strategy of how to communicate. No?

DR. HAMDAN: True. True. But I just want to make it in simple terms. The simple terms are if you look at --

CHAIRMAN RYAN: Drinking water is safe is pretty simple.

DR. HAMDAN: You can talk -- you can spend many lives talking about radiation and then arguing about the -- whatever, which is fine, you need to educate people. But in the case with NRC, this is being done at the expense of not doing what NRC has recommended it should be doing, and that is going out and emphasizing, as a concept and more often than not, okay, we recognize radiation is -- you know, is potentially unsafe, but that's how we go about regulating it, and that's how we report it to the public.

And that should be the message. That

should be the subject, not radiation. The subject should not be radiation. The subject should be how we go --

CHAIRMAN RYAN: Well, to be --

DR. HAMDAN: -- about doing --

CHAIRMAN RYAN: To be fair to our speaker, that's -- we asked him to talk about the radiation piece today, not the whole program. So I think, just to be fair, there are other elements of that website that we didn't go into.

DR. HAMDAN: I'm trying to help.

CHAIRMAN RYAN: No, no, that's fine. But --

DR. HAMDAN: This is not just one presentation. This is -- you know, I've been through this, you know, public communication for a long time, and an advocate of it. But some big part of me thinks that we don't pay attention to the strategy. We don't pay enough attention to the entire strategy. And, frankly --

CHAIRMAN RYAN: That's why we're here today. We're thinking about it.

DR. HAMDAN: Okay. I think I've said enough.

CHAIRMAN RYAN: Okay.

MR. FLACK: Mike?

CHAIRMAN RYAN: One last question. They're over time.

MR. FLACK: Just one comment. This is John Flack, ACNW staff. Generally, the agency regulates with a margin. There is usually a margin to some unsafe condition. In this case, the margin is -- if there is a threshold, the idea would be a perception in putting across that the margin may have been reduced, but there is still margin.

And I think that's the piece that does not come across in an area where you're looking at a graded -- that you're trying to understand how this graded -- you know, getting lower and lower and it provides greater and greater safety, rather than using, as we do in reactor space, establishing margins to safety, so that maybe the margin has been reduced and that's the perspective, but it has not been exceeded into an unsafe condition.

And that point I don't see come across when -- you know, in this kind of approach where you're looking at something in its holistic form in various part -- you know, fluctuations within that form. So I think that might be part of the problem understanding this. I mean, you could say it's safe,

but then the question is, well, how close is it to being unsafe?

And I think the point being made is is there is still margin there that provides the protection that the agency is trying to establish in protecting the public health and safety. And I think that's the message that really needs to be coming across. I don't see that as often here. It's a different perception.

CHAIRMAN RYAN: It's an interesting conundrum. You know, on the other hand, in certain arenas -- and I'll pick a medical one -- the doctor says your appendix has to come out. You're in pain, you're in the emergency room. You need to sign these consent forms.

Now, there's seven pages of detailed information on risks of anesthesia, risks of this, risk of infection. You name it. Did anybody read it? Sign here; we'll fix it. What are my chances, Doc? Well, they're real good. This is one we do every day.

So there's an element of, you know, kind of just factual, detailed, technical communication, and then there's, you know, communicating either confidence or a lack of it. And I think that's -- you know, we're sort of all wrestling with that thought.

MR. McINTYRE: And we could expand that into how we present all of the information, especially on the website. And I could go on with my own personal ideas on that, but some other time perhaps.

CHAIRMAN RYAN: Sure. No, and it's a good dialogue, and, again, we're exploring it, because the Commission has asked us to think about --

MR. McINTYRE: Sure.

CHAIRMAN RYAN: -- this question and its direction to us in its non-interaction plan, and we -- Dave, you've really given us a real good launch-off point here in what's on the website and what materials are out there, so we can begin our thought process. We really appreciate your coming down and being with us today.

Thank you very much.

MR. McINTYRE: I appreciate all your insights and advice, and I'll take them back.

CHAIRMAN RYAN: Okay, great. Any other comments? Questions?

(No response.)

All right. Without further ado, we'll move to our second briefing, and I think Mr. Christopher Brown of the ACNW&M staff is going to provide us with a basic primer on high-burnup spent

fuel and cladding. And this is a followup briefing on some other issues we've had on burnup credit and other issues for the past few meetings.

Chris, we appreciate your being here and --

MR. BROWN: Thank you.

CHAIRMAN RYAN: -- helping us learn. Thank you.

MR. BROWN: Good morning. The Committee asked for some basic information on spent fuel, spent fuel cladding, and assemblies. And Bob Eisinger's name was mentioned at first, and Bob has served as my mentor for a number of years on this issue. So what we decided to do is that I would give the presentation, and Bob may chime in on a few subjects and would be available for questions.

And there's Bob right there, considered probably one of the -- probably one of the experts in this area in the U.S., probably worldwide also. And so without any further ado, I'm going to go right into the presentation.

I just also want to mention that each of the slides that I have can be developed into four or five additional slides. But I just wanted to tell you some of the concerns that probably the staff will have

and that the ACNW may be faced with. We've already looked at moderator exclusion, and Albert Macchio gave us a presentation a few months ago, and he was going to try to go into some more detail on work that has been done on spent fuel cladding. I had curtailed his presentation.

But definitely Part 71 and Part 72 have information about maintaining criticality. Part 72 does call out no gross degradation of the fuel, but also we want to prevent release of radioactive material. Part 72 says that you should have retrievability of the spent fuel assembly. Many interpretations on what that means in Part 72.

But also, it's the starting -- when the fuel comes out of the reactors, the starting point of disposal. I was talking to one of my neighbors one time, and I was -- I made a comment, and this slipped out, that she had a small kitchen. And she said to me, "Well, this is just what I'm dealt with, and I have to deal with it." And this is what the staff has to do.

You know, and basically when the fuel comes out of the reactor, it goes to the pool, it's the starting point of disposal. It comes out damaged, it comes out with a lot of crud on it, it comes out

with oxidation, breaches, and this is what the staff has to deal with.

Also, transportation source term is a particular issue for high-burnup fuel. And this is -- I put this as a question, because I think this will come up in the Yucca Mountain license application, you know, whether the cladding is a barrier for isolation.

I just wanted to mention -- I put up all of these different reactors, because, you know, when we're talking about spent fuel, it's a big subject. I mean, we have a lot of different reactors out there, and there's a lot of different fuel assemblies. And so I'm going to try to narrow this down, and, of course, my primary focus will be on the PWR and BWR or LWR fuel assemblies.

Bob, do you want to say anything about that? Anything important about this slide? This is Bob.

MR. EISINGER: Just that it's there to point out spent fuel is not a homogeneous thing. People talk about spent fuel like it's a thing. It's more like a collection of things, a big collection.

CHAIRMAN RYAN: It's at least 12, we know that.

(Laughter.)

MR. EISINGER: Many subcategories.

CHAIRMAN RYAN: Many subcategories, I'm sure.

MR. BROWN: This is a typical PWR fuel assembly right here, and you can see it is imposed on many parts. Of course, my presentation will focus on the fuel tube or the cladding, which is normally zirconium, and also the pellet, which is normally UO_2, but there are different materials for the pellet.

When we look at the fuel assembly, it's basically two parts. You have the rod and the hardware. In terms of the rod, you have fuel. It can be UO_2, MOX, metal. In terms of the cladding, you can have zircalloy-2, zircalloy-4. We also talk about zirconium alloys. In particular, we talk about the -- well, the ZIRLO is a cladding that falls in that category. Also, M5.

I'll talk a little bit about the zirconium alloys, because they're the newer claddings that were designed for improved reactor performance. Also, you have aluminum and stainless steel cladding. We find the stainless steel claddings on older fuel types.

In terms of the hardware, they're listed right there. If we go down to maybe like where you see the wrappers, you'll see -- I will show you what

a wrapper is around a BWR fuel assembly. BWRs also have debris filters, like -- plants like River Bend have had some problems with crud, and so the fuel vendors have developed these debris filters to catch some of the particles. Also, it's mainly because of the problems due to water chemistry.

When we talk about the PWR fuel characteristics can be anywhere from 14 by 14 to 18 by 18 arrays, we're looking at anywhere from maybe about -- maybe about 164 to about 200 rods inside of an assembly. It could vary, maybe 179 to 264 fuel rods. There are three manufacturers. I have a chance to visit these manufacturers. You're talking about Westinghouse, Global Nuclear Fuels, and one is slipping me -- Areva. Okay.

There are different cladding types. As I said, I'm going to talk a little bit about the cladding types, in particular the zirc-4 versus the ZIRLO, and the issues associated with that.

When we talk about rods, you have full and partial length rods. Rods are pressurized. This pressure can change inside of the rods, leading to degradation mechanisms, which I'm going to talk about such as creep. Cladding thickness and conditions can vary due to the way in which they were fabricated,

such as annealed. You'll find cladding thickness on the BWRs are different than the PWR claddings.

Fuel enrichments vary. You have burnable poisons. For example, the ZIRLO rod manufactured by Westinghouse, they have a particular assembly in which their -- one of the fuel pellets are coated with boron, and it serves as a burnable poison. But this here can also be a problem, because the boron interacts with the chemistry of the material and increases the actual pressure in the cladding and can cause very high hoop stresses.

I'll say a little bit more about that later.

I couldn't get this here reversed properly, but this is a BWR fuel assembly. And you can see the -- the BWR is very interesting, because they have these wrappers around it. And BWRs have problems with -- you'll find that they have problems with crud buildup. River Bend had reported some problems with crud buildup.

They also have these control rods, and you can see how they look below, and the blades.

When we're talking about the BWR fuel rod, you have anywhere from 6 by 6 to 10 by 10 arrays. the cladding thickness is different, because of the way

they are fabricated, and the rod arrangements are also different. The BWRs also have these water channels in them also.

Now, to talk a little bit about the cladding, we are very familiar with zirc-2 and zirc-4, but now we're starting -- you may start to hear about ZIRLO and M5. What are they? What makes them different?

Well, clearly, you can see that the ZIRLO and M5 do not have any chromium or nickel, but they do have approximately one percent niobium. And the reason why they were developed by the industry is for improved reactor performance. Zircalloy-4 has a problem with oxidation.

The industry went to ZIRLO because their notion was that this improved material -- and I'm sure they've done a lot of the tests -- lead test assemblies, in which they looked at the performance, that it has a less oxidation pickup. But we're finding that ZIRLO actually does not have a -- it still have a very affinity for hydrogen pickup.

The M5 is working pretty well in the reactors, and we don't have much of a problem with that concerning hydrogen pickup. So, but the main thing here is I wanted to show you, we talk about

these different cladding types, zirc-2, zirc-4, ZIRLO, M5. And there are others, but these are the main ones. But the main difference is that the ZIRLO and M5 do not have any chromium or nickel.

And this is just to reemphasize a little bit more about the ZIRLO, because this is what's in the reactor now and what will be in storage. But basically, you have an elimination of chromium. And if you go to almost that last bullet, where I talk about high-duty plants, you're seeing some corrosion levels up to 100 microns for the ZIRLO. So it's not as good as initially they thought it was going to be. The physical properties of ZIRLO are very similar to those of the zirc-4 clad.

One of the main limitations of zirconium alloys: they like hydrogen. And because of the interaction inside of the water in the reactor, it causes a problem with oxides. So when you absorb the hydrogen, you can have brittle zirconium hydrides in the zirconium matrix. And this -- the notion is is that you have a problem with stresses in the cladding, which can then affect the structural integrity of the cladding, possibly during transport or maybe there could be a problem in the repository.

I kind of put this picture up here. I

call it limitations in zirconium alloys. I guess you could call it also the origins of stresses in zirconium alloys. You know, basically, the first picture shows cladding prior to service. You just have your zirconium metal, but once it's in service you just develop this oxide. That's just going to happen. Some claddings have more oxides than others.

If you go down to the one that's showing the pellet, you can see that your -- you can see the -- you can see that you can also develop some cracks inside of the oxide, but also you can develop hydrides inside of the cladding.

And this is going to be a subject I'm going to talk a little bit about is the hydrides inside of that metal cladding, how you can have a phenomenon that's going to -- probably you're going to hear a lot about is hydride reorientation. If we get more involved with probably details looking a moderator exclusion, and the industry has been complaining about we need to resolve this issue of transportation of high-burnup fuel -- and in terms of the repositories, you know, whether or not hydride -- delayed hydride cracking is a problem.

Degradation modes of rods -- I've got degradation twice there, excuse me. You can have

general and localized corrosion, you can have spallation of the oxide in which you can have some of it break off. You can have creep. You can have fuel and cladding oxidation, and I'm going to show you how you can actually have the fuel oxidation. I think that's going to be of interest to some people.

You can have pellet cladding interaction failure and hydride reorientation. By no means did I name them all. But this here is sort of a pictorial diagram that actually shows you some of the modes of fuel degradation -- rod degradation where they are. You can see creep rupture. That's basically a function of stress, temperature, and time. Actually, a constant stress.

You could have stress corrosion cracking, external oxidation, hydride reorientation, fuel pellet oxidation. So basically, to get that fuel pellet oxidation, you've got to have some type of air getting to the root, the cladding, to the actual fuel pellet. And this is a problem, and we've had several issues concerning this here. One was -- actually, it was two issues.

I can only think of one right now where an applicant was interested in loading a cask in which -- I'll give -- let Bob shed some light on -- briefly on

that situation of oxidation that can occur during the blowdown of -- when you're removing water from the cask.

MR. EISINGER: There was an applicant who wanted to blow the water out of his cask prior to welding it, using air, and we required him to control the temperature, so that he wouldn't oxidize the fuel if there had been any failed fuel in the cask.

MR. BROWN: This is just another pictorial diagram here. I show how you can -- what's spalled oxide, and also you can see some hydrides. Radial cracks in the oxide can occur, and also I wanted to show hydrides also, and my point when I wanted to show the hydrides was that the hydrides tend to migrate to the cooler regions of the cladding.

Oxidation of cladding of high-burnup fuel -- what causes this? The water-side corrosion from when it's inside of the reactor. There is a chemical reactor that occurs, and you get zirconium hydrides that are formed. That's just a fact. You're just going to have hydrides that are formed. When the fuel is inside the reactor and comes out of the reactor, the PWRs tend to have the hydrides in a circumferential direction.

The Bs are -- tended to be more randomly

oriented. Now, that's not the hydride reorientation. That's when it comes out of the reactor. That's just due to reactor operation. Hydriding increases with increasing burnup.

Now, hydride precipitates are formed in the reactor, generally circumferentially oriented in the PWR cladding and randomly oriented in the BWR cladding. That is what I just said earlier without that slide.

But how are the radial hydrides formed? Hydrides form as the fuel cools in the reactor pool. Now, during the loading conditions we actually had the canister inside of the pool, and went and -- when the canister is removed from the pool, you actually have to drain the water out. And this is probably when the fuel probably sees its highest temperatures.

And so, basically, during the short-term operation, you can have actually hydrogen that goes into solution. So for high-burnup fuel, hydrogen can go back into solution. Look at the last bullet. Upon cooling, hydrides will precipitate into the radial direction, but there are some caveats there. It has to be under a particular stress in order for them to reorient in a radial direction.

Now, we know that once we're done the

loading we put the lid on the canister, and the canister goes out to the pad. So we actually have temperatures that are decreasing, so that's what I'm saying. When the temperatures decrease, it's a possibility that the stresses would be high enough for them to change directions.

Do you want to say anything more about that?

MR. EISINGER: The stresses in most rods is going to be too low to cause hydride reorientation. But there is a segment of the population that either because of the way it was -- fuel was operated and had a high fission gas release, or because the way the fuel was manufactured and has a burnable poison which generates more gas, that you'll have a higher pressure. So there will be some part of the population that will fall in the spectrum where this mechanism could be active.

MR. BROWN: And this would be a problem in transportation. Could be.

MR. EISINGER: The industry likes to think we say that there's going to be catastrophic results from this. What we really say is we don't have enough information to determine what the results will be.

MR. BROWN: As a side note, this afternoon

I will tell you what the industry is saying about that, and how they want NRC to move.

Hydride reorientation is basically the materials' phenomenon of hydride reorientation, and zirconium-based alloys usually involves the dissolution of circumferential hydrides and the formation of zirconium hydrides oriented perpendicular to a hoop stress.

And this is basically what the hydrides look like. The first picture shows circumferential hydrides and irradiated zircalloy cladding. As I said, that's what it could be as it comes out of the reactor. And then, this second one shows you have mixed hydrides, and the final one shows radial hydrides.

And this was actually your work here done at Argonne.

MR. EISINGER: Battelle Columbus.

MR. BROWN: What's the problem with UO_2 exceeding 45 gigawatt days per MTU? Again, if I didn't mention to you, we consider anything above 45 gigawatt days per MTU as high burnup. I was never really sure how we actually determined that anything about 45 was -- how that actually came about, and I believe it probably was based on data, and maybe you

see a change in a curve.

MR. EISINGER: There is nothing holy about 45 gigawatt days per metric ton. Maybe it's 42, maybe it's 48. But that's -- in that general burnup range is where many of the properties of the fuel start going from a linear low value to an exponential value. There's a change in the shape of the curve where things get a little dicier.

MR. BROWN: Okay. Thank you.

UO_2 fuel undergoes significant changes at higher burnups. You can have changes in chemical composition, and also formation of a rim structure. In fact, you know, I have seen a rim structure, I tried to get a picture of a rim structure, so you could see that here. But I sent Bob an e-mail asking him to really kind of define, what is the definition of "rim structure" on the fuel? Want to share that?

MR. EISINGER: Well, there's a number of definitions of rim structure, but basically, as you go to higher burnup, due to the epithermal neutrons in the outer region of the pellet, you generate more plutonium, and so you have a buildup of plutonium, which is about double what it is in the main part of the pellet.

You also have a restructuring of the

pellet where normally you might have grains of 10 to 12 microns average diameter, now you have grains in the order of 1 micron average diameter. Also, your fission gas release in that region is very low. The gas tends to remain in the bubbles that are formed between the grains.

This region can extend maybe 150 microns into the pellet from the outer surface.

MR. BROWN: Thank you.

Second bullet says these changes become more prominent as the burnup increases. You can have thermal gradients that could cause pellet cracking, and as the pellet swells you can actually have a pellet cladding gap -- starts to close. And this also starts to develop stresses on the cladding.

Oxidation of spent fuel -- I know that Neil has had a lot of questions concerning this here, and I think he has some questions on this issue. Irradiated uranium dioxide exposed to an oxidizing atmosphere will eventually oxidize to U_3O_8. And there's a chemical equation that shows that, and it's an Ahrennius equation which is a function of time and temperature. And you also have an increase in volume due to the oxides that are formed, and it induces the circumferential stresses in the cladding.

So this is also another area that we are concerned about in terms of during the loading operations and also some issues concerning the repository.

In summary, what I just wanted to highlight for you, what we do know with respect to the issues concerning high-burnup fuel, in terms of the fuel structure for -- and I have low burnup fuel and high, I just called it low and high. In terms of the rim structure, there is none for low-burnup fuel, but, however, for high-burnup fuel what we know about -- that outer 8 to 10 percent of the fuel volume has a rim structure with submicron grain size.

In terms of the fuel cladding gap for low-burnup fuel, it's open. For high-burnup fuel it may be open or closed, depending on the burnup and storage temperature due to pellet swelling.

Do you want to say anything additional on that?

Okay. In terms of the fuel structure, for low-burnup fuel, when we talk about the grain boundary bubbles, there are some bubbles in the structure on grain boundaries. For high-burnup fuel, you have a higher fission gas release, indicates more open grain structure. In terms of the radionuclide distribution

and inventory, we know for low-burnup fuel it's open, for high-burnup fuel there is excess actonides in the rim region. Bob just said something about that.

And, finally, we know about the claddings for low-burnup fuel. Most are zirc-4 and zirc-2. I've highlighted that the problem with the zirc-4 and 2, they have problems with oxidation. They just have an affinity for high hydrogen pickup.

Industry went to -- for higher burnup fuels, they went to newer alloys such as the M5 and ZIRLO, because -- the better reactor performance in terms of absorbing hydrogen. So less hydrogen, less oxidation.

Cladding defects that have been seen in zirc-4 and zirc-2 in low-burnup fuels have been pinholes and hairlines. But, however, in high-burnup fuels we're getting fretting defects, which can occur during -- where I showed you where spatial rates were.

Cladding composition -- less than 150 ppm of hydrogen for the low-burnup fuels. But, however, this is a very interesting range for the high-burnup fuel -- 70 to 700. Well, the M5 is probably the better performer in terms of the ZIRLO cladding, which is starting to see very, very high hydrogen pickups.

And so that was kind of a brief intro.

The hope is that we would probably get some feedback on what we would like to talk about more in detail, because this is just an intro, and if we need to come back and focus on another, you know, detailed topic we can.

So we can take a few questions.

MEMBER CLARKE: Chris, a very basic question, and it's kind of two parts I guess. This is Spent Fuels, not even 101, maybe it's 100. But often I hear term "damaged fuel." And if you could help me understand, what do you mean by "damaged fuel"? And I infer when I hear people talk about damaged fuel that the fact that it's damaged means that there are some things you can't do with it. Is that --

MR. BROWN: That's a very good question, because the staff has written several guidance documents on damaged fuel, and at one point they were discussing -- the document discussed that sometimes you may have missing grid spacers. There were a number of things that classified damaged fuel, but I think it would probably be best to tell you what the current definition that the staff sees as damaged fuel.

Now, I must emphasize -- I am going to ask Bob to explain that. I think that high-level waste

may have a different definition or interpretation of what they consider to be damaged, so I'll let you --

MR. EISINGER: Based on some recent IAEA meetings, we've revised the definition of "damaged fuel," basically saying now that damaged fuel was any fuel that can't perform the functions that's required of it, those functions being defined by regulations, by operational necessity, by handling.

MR. BROWN: So, you know, even a more general question: is a breach considered damage? You know, when one thinks of damaged fuel, they think of probably a pellet trying to get out or something like that.

CHAIRMAN RYAN: But could it be something as simple as the --

MR. BROWN: Crack.

CHAIRMAN RYAN: -- holding devices and the insert devices are twisted, and it won't fit in the position it's supposed to go into in the reactor. That's damaged fuel.

MR. EISINGER: Damage can be either to the rods or to the assembly.

CHAIRMAN RYAN: Right.

MR. EISINGER: Assemblies that have been deformed to the extent that they can't fit into the

basket would be considered damaged fuel, the most likely cause of that being excessive bow caused by the in-reactor radiation. But that would be considered damaged fuel.

As far as is a cladding breach a damaged fuel? In the past, due to some events that happened many years ago, there was regulations that were written that said that things that -- with pinholes and hairline cracks were not considered damaged fuel, but things -- rods that had gross breaches in it were considered damaged fuel -- no one ever defining what "gross breach" meant.

Latest guidance does somewhat define what "gross breach" means, but I have to say right now the question of gross breach as even being considered damaged is under reconsideration in the Spent Fuel Storage and Transportation Division.

MEMBER CLARKE: And the damage occurs while the fuel is in the reactor? While it's being transferred?

MR. BROWN: It can.

MEMBER CLARKE: Both or --

MR. BROWN: Most of the damage to fuel occurs while it's in the reactor. And just to put things in perspective, the number of rods that

actually breach, where the cladding is not intact, gaskets out of the cladding, is now less than .001 percent. So we're talking very few rods. Most of those breaches are caused because of what's called debris fretting. Somebody left some debris in the reactor coolant when they were doing some maintenance and it got up into the assembly.

But there are cases of damage occurring when assemblies have been dropped, when they have been handled in the pool and -- when they're transferred to the pool. Whether any damage occurs during storage, or during transportation, that's why we try to learn as much about the behavior of fuel, so we can set the conditions so that no further damage happens to damaged rods during those phases, and no undamaged rods become damaged during those phases.

MEMBER WEINER: Mike?

MEMBER CLARKE: That helps. Thank you.

CHAIRMAN RYAN: Chris, thanks for this tutorial. I don't have any questions at this point, but it sets us up for thinking.

PARTICIPANT: Could I make -- Chris, can you go back to your slide of the --

MR. BROWN: I'm not sure if all the members were done. I think --

MEMBER WEINER: Yes, if we could complete. Allen?

VICE CHAIRMAN CROFF: Yes, I'm -- if Jim was at 100, maybe I'm at 95. Something fairly basic here. As I understand what's going on here in very general terms, when we talk about the hydriding and oxidation, it's water-dissociating at the outer surface of cladding and forming an oxide layer on the outside, and then the hydrogen migrates inside and gets oriented one way or another. Is that --

MR. BROWN: Yes. And then, what happens is that for some reason -- and diffusivity equations can show this -- that the hydrogen tends to migrate to the cooler regions of the cladding.

Do you want to say more about --

VICE CHAIRMAN CROFF: Outside.

MR. EISINGER: Most of the hydrogen that's generated during the oxidative process of the cladding doesn't go into the cladding. You only get about 20 percent. That migrates into the cladding, and generally forms circumferential hydrides near the outer surface of the cladding.

In some cases, this layer of hydrides can be very dense and must really be considered just -- as unmechanically unsupportive and -- but during heatup

those hydrides go back into solution up to a certain extent, and then they can migrate, and they will migrate, sort of even out within the cladding width.

VICE CHAIRMAN CROFF: Okay. Now, what happens inside -- on the inside of the cladding with the tritium? Does the tritium form a hydride layer? Does it also migrate into the cladding? What goes on there?

MR. EISINGER: We really haven't looked at the tritium. Tritium is generated inside. I would assume that it behaves similar to hydrogen, seeing as that it's just an isotope. Physically, it should be indistinguishable. We haven't looked to separate the tritium and the hydrogen.

MR. DIAS: Okay. You said that only 20 percent of the hydrogen comes from actually the water, so the remaining 80 percent are actually fission product hydrogen?

MR. EISINGER: No, no, no, no, no. Eighty percent of the hydrogen generated during the oxidative process just goes off into the coolant water.

MR. DIAS: Oh, okay.

MR. EISINGER: Twenty percent that's generated goes into the cladding.

MR. DIAS: But that's the one that's in

the cladding, okay. That --

VICE CHAIRMAN CROFF: So what I'm hearing is we really don't understand much at all about the tritium layer on the inside. That has not been anything of interest.

MR. EISINGER: No.

VICE CHAIRMAN CROFF: Okay. Thanks.

MEMBER WEINER: Bill, one question. We're all --

MEMBER HINZE: Let me say -- well, Chris, I really appreciated this, but I find it also very tantalizing, because I would like to learn more and you indicated that you would be interested in some direction on that. And one of the directions that some of us are particularly interested in are associated with the volcanic scenario, the eruptive scenario, and the damage and fragmentation of the spent nuclear fuel by explosive activity associated with an eruption of a volcano. That could hypothetically happen in the -- at Yucca Mountain.

I hear you talk about cracking. I hear you talk about degradation. One of the concerns that we do have, of course, is the grain size of the erupted --

MR. BROWN: Right.

MEMBER HINZE: -- spent nuclear fuel, and getting down into the range where it can be inhaled, and thus be most detrimental to the RMEI. Can you in a few words provide us with any information about the strength characterization, the fragmentation, the cracking, and incipient cracks that might lead to grain sizes of the order that was mentioned here of 10 microns or less?

MR. BROWN: This information that you shared here has been shared also to me by Neil, and I passed it on to Bob. So there has been some discussions on this briefly. And do you have any information on this area?

MR. EISINGER: First off, a lot of the data needs in this area will be discussed in a paper that's coming out in Nuclear Technology in the month of August by myself and Carl Beyer of PNNL dealing with data needs for high-burnup fuel.

MEMBER HINZE: Excuse me. Is there any chance that we could get a pre-publication copy of the manuscript?

MR. EISINGER: I'll send something to Ruth.

MEMBER WEINER: Yes, that would be very helpful.

MR. EISINGER: As I mentioned before, the fuel is -- has two regions, one with a sort of normal grain size and has a -- and also a rim. There has been work done on the fracture of normal grain type structures, resulting in an equation that relates the fraction of material in the respirable size range to the impact energy on the grains. This is in a DOE handbook. For all we can determine, the estimates in that handbook are probably a factor of 10 higher than they need to be to support the data.

We come to the grain -- to the rim, which is a particular concern to us in transportation also, because if there is an accident or something you have already got material that's in the respirable grain size range. I'm talking about .1 to 1 micron grains.

We don't have a lot of information on how that particular material reacts to impact. You have some work out of the Germans who have used some micro-hardness probes, and say that the -- in fact, the material in the rim region is more cohesive than in the larger grains.

We find to have some issues with that, because the probes are still large with respect to the grain size, and, on the other hand, we have a lot of anecdotal evidence that any time anybody has tried to

handle the fuel with the rim on it in order to make metallographic/ceramographic samples or prepare samples for any other type of analytic technique, the material just crumbles away.

And so we've got two diverging schools on that, and, of course, that is identified in this paper as one of those areas that could make an impact on the release fractions that you get from accidents.

MEMBER HINZE: Well, one of the things that I noted in your discussion was -- in your first statement is the heterogeneity of the spent nuclear fuel. And it seems to me casting a blanket description that it's strong or it's weak or we get this type of range of sizes perhaps is unwarranted in view of the lack of homogeneity.

And I'm also wondering if we're going to be putting fuel into Yucca Mountain that's tens of years old. How have the spent -- how have fuel rods changed since the early days of commercial reactors?

MEMBER WEINER: I'm going to -- because we're almost 20 minutes late, I'm going to really interrupt this, because we will revisit this. So if in a few sentences you could respond, Bob, and then I think I will turn it back over to the chair.

MR. EISINGER: It is a very -- spent fuel

is very heterogeneous. We've cut down a lot of that heterogeneity by just looking at LWR fuel. The conclusions that we're drawing are based on the spectrum of evidence that we have, what generally appears to be the case. Can we put probabilistic states with 95 percent confidence? No, we cannot.

MEMBER HINZE: Well, Madam Chair, if I might as a matter of privilege here suggest, of course, faction to Chris, because you asked for further information. I would suggest that those of us that are interested in this topic receive a copy of this manuscript, review that, and then have the option of having further briefings for a group of the Committee or the entire Committee, whichever seems appropriate to the chair.

Thank you.

MEMBER WEINER: I think it would -- it is going to be important to revisit this topic, because I have some unanswered questions, and we simply have run out of time.

But thank you very much, Chris, for an excellent presentation.

CHAIRMAN RYAN: Before you leave, Chris, let's summarize. And, Bill, I agree with you. I think there's a couple of areas where we could expand.

One would be questions related to the igneous event. Of course, you'd better factor in the fact that there's a TAD and a disposal container as well, and there's lots of things that could happen there.

Second is the area of transportation of the materials. We certainly have, you know, risk analyses that go in there, and some of these issues might play into what happens during a transportation accident of one sort or another. There's a wide range of things there, so there's a second area there.

And then, the third could be, although we did see some information that indicated at least so far not much of what happens to spent fuel when it's stored on a pad in a dry storage cask for a long period of time, we did have one report on an examination of a canister that was reopened at some point down the line from initial loading and --

MR. EISINGER: I examined that.

CHAIRMAN RYAN: Huh?

MR. EISINGER: I examined that.

CHAIRMAN RYAN: You did. So, and the question was -- or the answer seemed to be, from what was reported to us, well, not a lot changed since the day we closed it up. So there's a wide range of questions there. I think with this initial tutorial

we have sharpened our thinking and maybe -- I agree with you, I think there's more than one topic that we could certainly look at in more detail.

MEMBER WEINER: Let me add a fourth topic, and that is if there is a buildup of fissile material around the rim, does that have an impact on the probability of criticality during transportation?

CHAIRMAN RYAN: Boy, that would be a tough one. I don't think so. This is just a little -- but, yes, that's another question. Sure, there's lots of interesting things to think about. So I think we're all agreed that we will certainly work with Chris and his colleagues to maybe bring the issues further up.

Sir, you had a point you wanted to raise, and I didn't want to leave without at least giving you the chance to --

MR. SCOTT: Thank you. I'm Harold Scott from the staff. In the graph, Chris, slide 9 that showed the composition, there is no tin in M5.

MR. BROWN: Okay.

CHAIRMAN RYAN: I'm sorry. That's slide 9?

MR. BROWN: Thank you. I don't know how that got in there.

CHAIRMAN RYAN: There's no tin in M5.

MR. SCOTT: Right.

CHAIRMAN RYAN: So that should be a zero. Okay. That's the first column, tin. In M5 fuel, there's no tin.

MR. SCOTT: And there is oxygen in ZIRLO, in the last column.

CHAIRMAN RYAN: All right. Great. Thank you.

MR. BROWN: All right. I took this from another publication, so thank you for -- for correcting that.

CHAIRMAN RYAN: Thank you.

With that, we will take our 15-minute scheduled break.

We are going to close the formal part of our record. We're going to have some informal discussions among members and staff members. It's a session that's open to the public. We will reconvene at 25 of 11:00.

Thank you all.

(Whereupon, at 10:20 a.m., the proceedings in the foregoing matter went off the record.)