

# NUCLEAR REGULATORY COMMISSION

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180th Meeting

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S  
ADVISORY COMMITTEE ON NUCLEAR WASTE

June 20, 2007

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This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

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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

+ + + + +

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        |

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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

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I-N-D-E-X

AGENDA ITEM

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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

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

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

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

14 (Laughter.)

15 CHAIRMAN RYAN: Very good.

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

19 CHAIRMAN RYAN: There you go.

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

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

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

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

22 Now, I'd like to start off --

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

25 MR. McINTYRE: Sure.

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

6 MR. McINTYRE: I put them to sleep  
7 already.

8 (Laughter.)

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

12 MR. McINTYRE: Okay.

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

15 MR. McINTYRE: There he is.

16 CHAIRMAN RYAN: Hello, Charles. Good  
17 morning.

18 MR. FITZPATRICK: How are you?

19 CHAIRMAN RYAN: Fine. Thanks for being  
20 with us.

21 MR. FITZPATRICK: Thank you.

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

24 (No response.)

25 Guess not, so we'll proceed.

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1 MR. McINTYRE: Okay.

2 CHAIRMAN RYAN: Thank you again for the  
3 interruption.

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

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

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

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1 like that.

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

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

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

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

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

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

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

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

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1 the Chairman or the other Commissioners, as they  
2 request.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5 So that means when you go to [www.nrc.gov](http://www.nrc.gov),  
6 there's a box there on the right of key topics, and  
7 there is now a link to radiation protection, which  
8 gathers all the information that we already had on the  
9 website and puts it in one convenient page. So it's  
10 basically taking the information we had, bringing it  
11 together, and putting it closer to the surface. And,  
12 hopefully, that will make it easier for somebody to  
13 find if they -- if they come to our website looking  
14 for information about radiation.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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1 agree on a change to key topics.

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

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

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

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1 second.

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

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

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

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

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

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

12 (Laughter.)

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

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

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1 this task.

2 Thank you.

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

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

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

23 MR. McINTYRE: Right.

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

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

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

7 CHAIRMAN RYAN: Sure.

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

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

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

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

3 MR. McINTYRE: Sure.

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

8 MR. McINTYRE: Yes.

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

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

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

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

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

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

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

21 MR. McINTYRE: Sure.

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

25 MR. McINTYRE: Right. I know that my

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

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

11 MR. McINTYRE: Okay. Thank you.

12 CHAIRMAN RYAN: Thank you.

13 Professor Hinze?

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

18 MR. McINTYRE: Dramatically.

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

25 MR. McINTYRE: Reading a pamphlet, yes.

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

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

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

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

24                   MR. McINTYRE: I don't know.

25                   MEMBER HINZE: Thank you.

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1 CHAIRMAN RYAN: Allen?

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

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

14 (Laughter.)

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

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

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1 maybe this kind of stuff, or --

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

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

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

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

18 VICE CHAIRMAN CROFF: Okay. Thanks.

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

23 MR. McINTYRE: Yes.

24 CHAIRMAN RYAN: -- all of that.

25 MR. McINTYRE: Yes, right.

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1 VICE CHAIRMAN CROFF: Okay. No.

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

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

7 CHAIRMAN RYAN: No, no.

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

10 CHAIRMAN RYAN: I could tell.

11 (Laughter.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

13 MR. McINTYRE: Thank you.

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

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

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

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

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

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

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

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

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

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

5 MR. McINTYRE: Yes.

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

9 MR. McINTYRE: Okay.

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

12 CHAIRMAN RYAN: Dr. Clarke?

13 MR. McINTYRE: You're welcome.

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

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

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

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

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

18 There may be some other things out there  
19 that --

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

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

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

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

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

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

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

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

7 MR. McINTYRE: Definitely.

8 MEMBER CLARKE: Thank you.

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

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

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

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

15                           (Laughter.)

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

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

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

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

7 MEMBER CLARKE: Okay.

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

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

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

21 MR. McINTYRE: Not that we have.

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

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1 concerned about their health they call up their  
2 doctor.

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

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

16 MEMBER WEINER: May I make another  
17 comment?

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

20 MEMBER WEINER: Sure.

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

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1 clearly see a threshold in their analysis of  
2 epidemiologic data.

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

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

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

23 MR. McINTYRE: Right.

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

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

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

6 CHAIRMAN RYAN: And I agree with that.

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

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

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

20 CHAIRMAN RYAN: Right.

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

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

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1 radiation question. A lot of things get mistranslated

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

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

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

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

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

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

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

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

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

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

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

16                   CHAIRMAN RYAN:   Sure. Yes, absolutely.

17                   MR. McINTYRE:   Using those analogies.

18                   CHAIRMAN RYAN:   I appreciate that.

19                   Let's see. Do you have another question?

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

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

5 CHAIRMAN RYAN: So what's the question?

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

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

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

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

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

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

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

10 MR. McINTYRE: Well, that is our emphasis.

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

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

25 And instead of emphasizing radiation,

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

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

9 CHAIRMAN RYAN: What's the question,  
10 Latif?

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

15 CHAIRMAN RYAN: Let me help you, Latif.

16 DR. HAMDAN: Yes.

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

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

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

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

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

12 CHAIRMAN RYAN: Drinking water is safe is  
13 pretty simple.

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

25 And that should be the message. That

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

4 CHAIRMAN RYAN: Well, to be --

5 DR. HAMDAN: -- about doing --

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

11 DR. HAMDAN: I'm trying to help.

12 CHAIRMAN RYAN: No, no, that's fine.

13 But --

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

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

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

25 CHAIRMAN RYAN: Okay.

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1 MR. FLACK: Mike?

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

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

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

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

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

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

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

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

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

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

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

8 MR. McINTYRE: Sure.

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

16 Thank you very much.

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

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

21 (No response.)

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

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

4 Chris, we appreciate your being here  
5 and --

6 MR. BROWN: Thank you.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

25 (Laughter.)

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1 MR. EISINGER: Many subcategories.

2 CHAIRMAN RYAN: Many subcategories, I'm  
3 sure.

4 MR. BROWN: This is a typical PWR fuel  
5 assembly right here, and you can see it is imposed on  
6 many parts. Of course, my presentation will focus on  
7 the fuel tube or the cladding, which is normally  
8 zirconium, and also the pellet, which is normally UO<sub>2</sub>,  
9 but there are different materials for the pellet.

10 When we look at the fuel assembly, it's  
11 basically two parts. You have the rod and the  
12 hardware. In terms of the rod, you have fuel. It can  
13 be UO<sub>2</sub>, MOX, metal. In terms of the cladding, you can  
14 have zircalloy-2, zircalloy-4. We also talk about  
15 zirconium alloys. In particular, we talk about the --  
16 well, the ZIRLO is a cladding that falls in that  
17 category. Also, M5.

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

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

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

7 When we talk about the PWR fuel  
8 characteristics can be anywhere from 14 by 14 to 18 by  
9 18 arrays, we're looking at anywhere from maybe about  
10 -- maybe about 164 to about 200 rods inside of an  
11 assembly. It could vary, maybe 179 to 264 fuel rods.  
12 There are three manufacturers. I have a chance to  
13 visit these manufacturers. You're talking about  
14 Westinghouse, Global Nuclear Fuels, and one is  
15 slipping me -- Areva. Okay.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

25 I kind of put this picture up here. I

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

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

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

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

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

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

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

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

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

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

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

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

25 The Bs are -- tended to be more randomly

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

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

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

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

25 Now, we know that once we're done the

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

7 Do you want to say anything more about  
8 that?

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

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

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

25 MR. BROWN: As a side note, this afternoon

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

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

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

16           And this was actually your work here done  
17 at Argonne.

18           MR. EISINGER: Battelle Columbus.

19           MR. BROWN: What's the problem with UO<sub>2</sub>  
20 exceeding 45 gigawatt days per MTU? Again, if I  
21 didn't mention to you, we consider anything above  
22 45 gigawatt days per MTU as high burnup. I was never  
23 really sure how we actually determined that anything  
24 about 45 was -- how that actually came about, and I  
25 believe it probably was based on data, and maybe you

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1 see a change in a curve.

2 MR. EISINGER: There is nothing holy about  
3 45 gigawatt days per metric ton. Maybe it's 42, maybe  
4 it's 48. But that's -- in that general burnup range  
5 is where many of the properties of the fuel start  
6 going from a linear low value to an exponential value.  
7 There's a change in the shape of the curve where  
8 things get a little dicier.

9 MR. BROWN: Okay. Thank you.

10 UO<sub>2</sub> fuel undergoes significant changes at  
11 higher burnups. You can have changes in chemical  
12 composition, and also formation of a rim structure.  
13 In fact, you know, I have seen a rim structure, I  
14 tried to get a picture of a rim structure, so you  
15 could see that here. But I sent Bob an e-mail asking  
16 him to really kind of define, what is the definition  
17 of "rim structure" on the fuel? Want to share that?

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

25 You also have a restructuring of the

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1 pellet where normally you might have grains of 10 to  
2 12 microns average diameter, now you have grains in  
3 the order of 1 micron average diameter. Also, your  
4 fission gas release in that region is very low. The  
5 gas tends to remain in the bubbles that are formed  
6 between the grains.

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

9 MR. BROWN: Thank you.

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

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

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

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

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

18           Do you want to say anything additional on  
19 that?

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

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

4 And, finally, we know about the claddings  
5 for low-burnup fuel. Most are zirc-4 and zirc-2.  
6 I've highlighted that the problem with the zirc-4 and  
7 2, they have problems with oxidation. They just have  
8 an affinity for high hydrogen pickup.

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

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

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

25 And so that was kind of a brief intro.

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

6 So we can take a few questions.

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

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

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

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

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

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

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

16 MR. BROWN: Crack.

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

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

23 CHAIRMAN RYAN: Right.

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

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

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

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

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

21 MR. BROWN: It can.

22 MEMBER CLARKE: Both or --

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

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

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

17 MEMBER WEINER: Mike?

18 MEMBER CLARKE: That helps. Thank you.

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

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

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

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1 MEMBER WEINER: Yes, if we could complete.

2 Allen?

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

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

15 Do you want to say more about --

16 VICE CHAIRMAN CROFF: Outside.

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

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

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

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

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

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

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

22 MR. DIAS: Oh, okay.

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

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

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1 the cladding, okay. That --

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

6 MR. EISINGER: No.

7 VICE CHAIRMAN CROFF: Okay. Thanks.

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

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

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

25 MR. BROWN: Right.

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1                   MEMBER HINZE: -- spent nuclear fuel, and  
2 getting down into the range where it can be inhaled,  
3 and thus be most detrimental to the RMEI. Can you in  
4 a few words provide us with any information about the  
5 strength characterization, the fragmentation, the  
6 cracking, and incipient cracks that might lead to  
7 grain sizes of the order that was mentioned here of  
8 10 microns or less?

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

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

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

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

24                   MEMBER WEINER: Yes, that would be very  
25 helpful.

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

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

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

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

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

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

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

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

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

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

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

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

16 Thank you.

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

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

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

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

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

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

18 MR. EISINGER: I examined that.

19 CHAIRMAN RYAN: Huh?

20 MR. EISINGER: I examined that.

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

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

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

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

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

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

20 MR. BROWN: Okay.

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

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

25 CHAIRMAN RYAN: There's no tin in M5.

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1 MR. SCOTT: Right.

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

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

7 CHAIRMAN RYAN: All right. Great. Thank  
8 you.

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

12 CHAIRMAN RYAN: Thank you.

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

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

20 Thank you all.

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

24

25

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on

Nuclear Waste

180<sup>th</sup> Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.



Charles Morrison  
Official Reporter  
Neal R. Gross & Co., Inc.

**NRC's**  
**Outreach on Radiation**

**Dave McIntyre**  
**Office of Public Affairs**  
**June 20, 2007**

# Objective

- Discuss NRC's efforts to inform the public about the health effects of low-dose radiation exposure.
- Discuss public perceptions of radiation.

# Key Message

In a real sense, *all* 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 any exposures as low as possible.

# What is OPA's mission?

- Assist the Chairman in carrying out his responsibilities as principal spokesperson for the NRC.



18-Jun-07

Office of  
Public Affairs



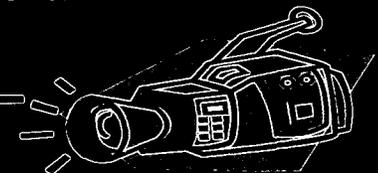
# What is OPA's mission?

- Act as the agency's primary link to the news media.
- Ensure openness in our regulatory process by making clear, accurate information available in a timely manner to the news media and the public about the NRC's policies, decisions, programs and activities.

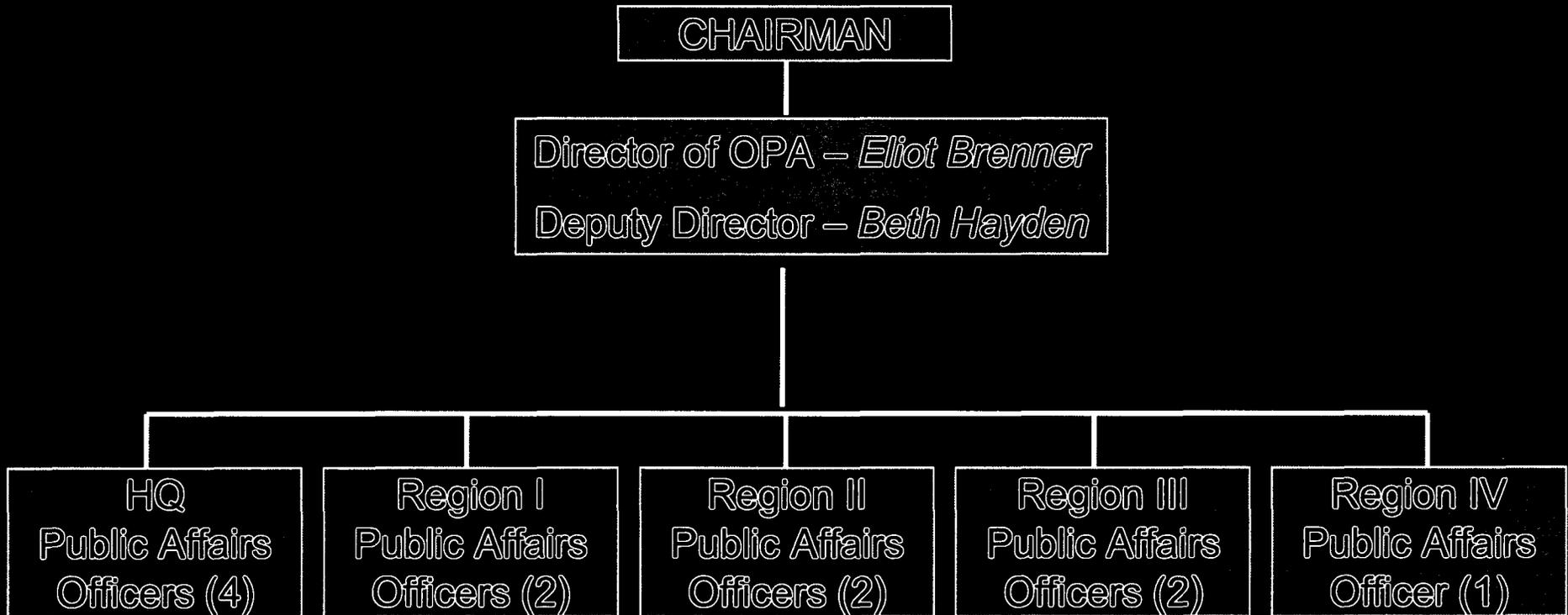


18-Jun-07

Office of  
Public Affairs



# Who are we?



*Public Affairs Officers have strong backgrounds in journalism, English or communication and extensive experience in the news business.*

Office of  
Public Affairs



# Who are we?

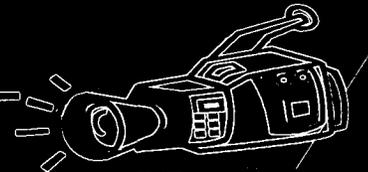
Headquarters: Eliot Brenner, Beth Hayden,  
Scott Burnell, David McIntyre,  
Holly Harrington, Ivonne Couret

Region 1: Diane Screnci, Neil Sheehan

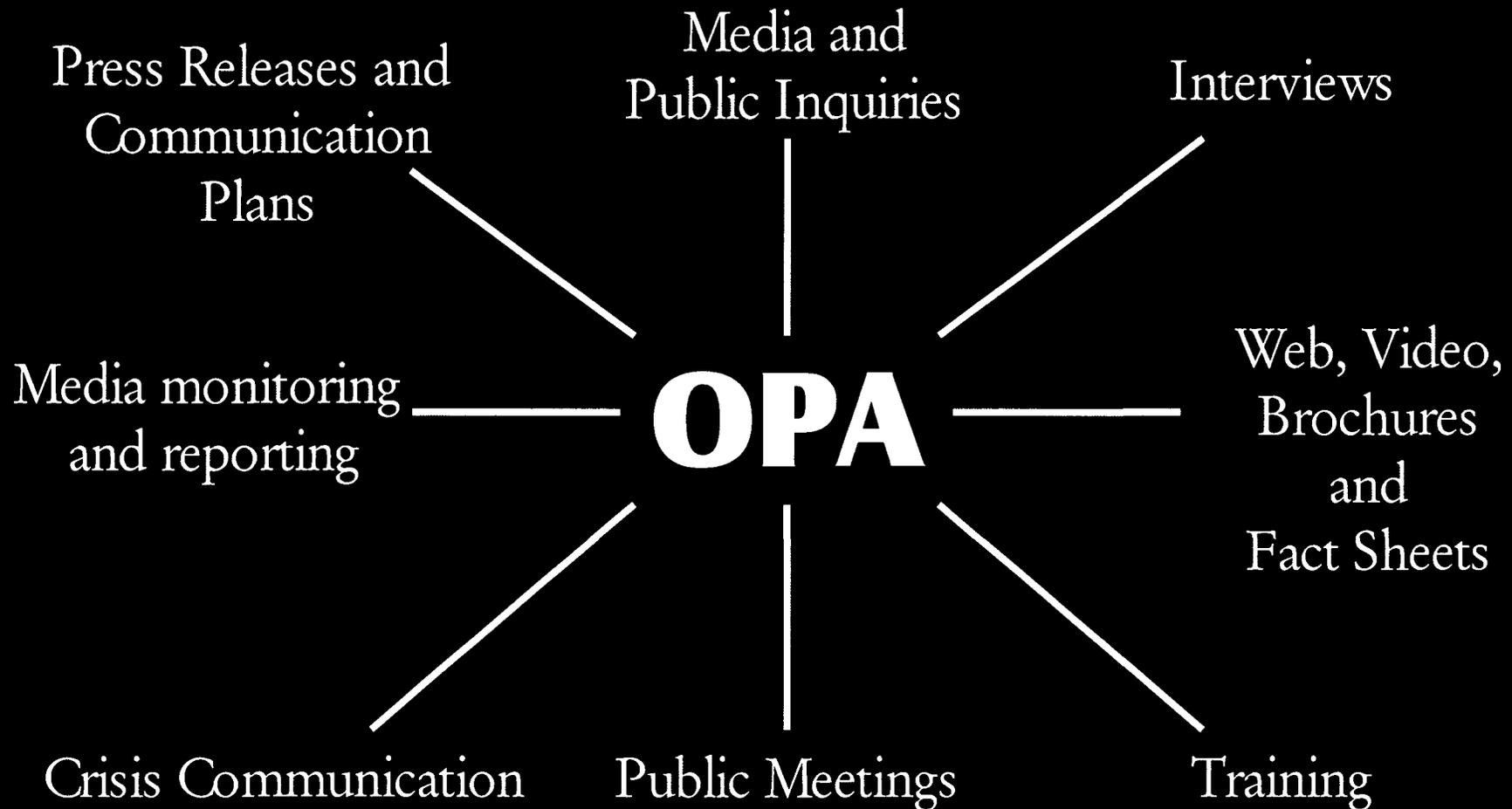
Region 2: Ken Clark, Roger Hannah

Region 3: Jan Strasma, Vika Mitlyng

Region 4: Victor Dricks

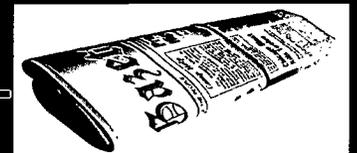


# What do we do?



18-Jun-07

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# NRC's Public Outreach Efforts (1)

## ■ OPA

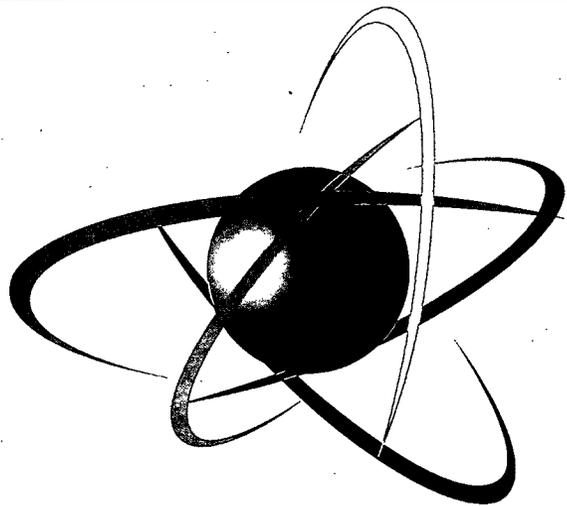
- Fact sheets and brochures
- Assist staff with Web content
- Special Web page for Students and Teachers
- Assist staff at public meetings
- Answer queries from the public and media
- “Advance work” for speeches by the Chairman or Commissioners

# NRC's Public Outreach Efforts (2)

- Program Offices and the Regions
  - ┌ NRR – Division of License Renewal
  - ┌ NRR – Annual Assessment meetings
  - ┌ NRO – New outreach effort underway to explain the Part 52 licensing process for new reactors
  - ┌ Tribal Outreach – NMSS High-Level Waste Outreach, FSME Uranium Recovery, OEDO
  - ┌ Inter-governmental organizations (CRCPD, IAEA)
  - ┌ Etc.

# NRC's Public Outreach Efforts (3)

- Agency-Wide Communications
  - ┌ Branding Initiative
  - ┌ Web site



# U.S. NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

*Protecting People and the Environment*

# Recent Initiatives

- “Radiation Protection” added as a “Key Topic” on the NRC Home Page at [www.nrc.gov](http://www.nrc.gov) .
- OPA and FSME looking at Web content to improve – and especially simplify – the presentation of information on radiation protection.

# What's on the NRC Web already?

- Pamphlets and Brochures, including “Radiation Protection and the NRC”
- Fact Sheets, including “Biological Effects of Radiation” and “Radiation Protection and the ‘Tooth Fairy’ Issue”
- Information about the sources of radiation and a “personal dose calculator”

# Public Perceptions of Radiation

- The public's main perception of radiation = danger



# NRC's Message

“Radiation can be either beneficial or harmful,  
depending on its use and control.”

*Radiation Protection and the NRC*

*NUREG/BR-0322*

*February 2006*

# NRC's Policy

- The “Linear Non-Threshold” theory of radiation exposure holds that there is no radiation dose that does not carry some measure of risk.
- That is not inconsistent with the previous message – the risk must be managed; BUT -
- Translated into “Plain English,” that means ...

# NRC's Policy, Translated?????

- “There is no such thing as a safe dose of radiation.”
  
- In even plainer English, “All radiation is harmful.”

*“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”--Dr. Karl Morgan, the father of Health Physics*

- NIRS Web Site

*“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.”*

– NIRS fact sheet on “Radiation Basics”

# Web Site Demo

NRC: Home Page - Microsoft Internet Explorer provided by USNRC

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address <http://www.nrc.gov/> Go Favorites NRC Pages »

Index | Site Map | FAQ | Facility Info | Help | Glossary | Contact Us  Google Custom Search  Search Options

## U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

*Protecting People and the Environment*

About NRC	Nuclear Reactors	Nuclear Materials	Radioactive Waste	Nuclear Security	Public Meetings & Involvement
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Employment	Report a Safety Concern	Event Reports	News & Information	Electronic Reading Room	Business with NRC
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Commissioner Edward McGaffigan poses with the five students who were Montgomery County Science Fair participants and winners of the...

### Key Topics

- Emergency Preparedness
- High-Level Waste Disposal
- Naturally-Occurring and Accelerator-Produced Radioactive Material (NARM) Toolbox
- New Reactor Licensing
- Radiation Protection

Local intranet

Start [Taskbar icons] 11:30 AM



# **A Basic Primer on Fuel: Assembly, Cladding, and Pellet**

**C.L. Brown**

**Advisory Committee for Nuclear Waste and  
Materials**

**US Nuclear Regulatory Commission**

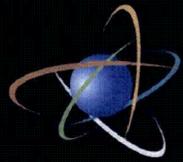


## **Why are we concerned about fuel behavior?**

- Maintain criticality
- Prevent release of radioactive material
- Maintain Retrievability
- Starting Point of Disposal
- Transportation Source Terms
- A barrier for waste isolation?

## Examples of Types of reactors

- PWR
- BWR
- CANDU
- VVR
- TRIGA
- SGHWR
- HTGR
- LMFBR
- Pebble Bed
- ATR
- New Reactor Designs



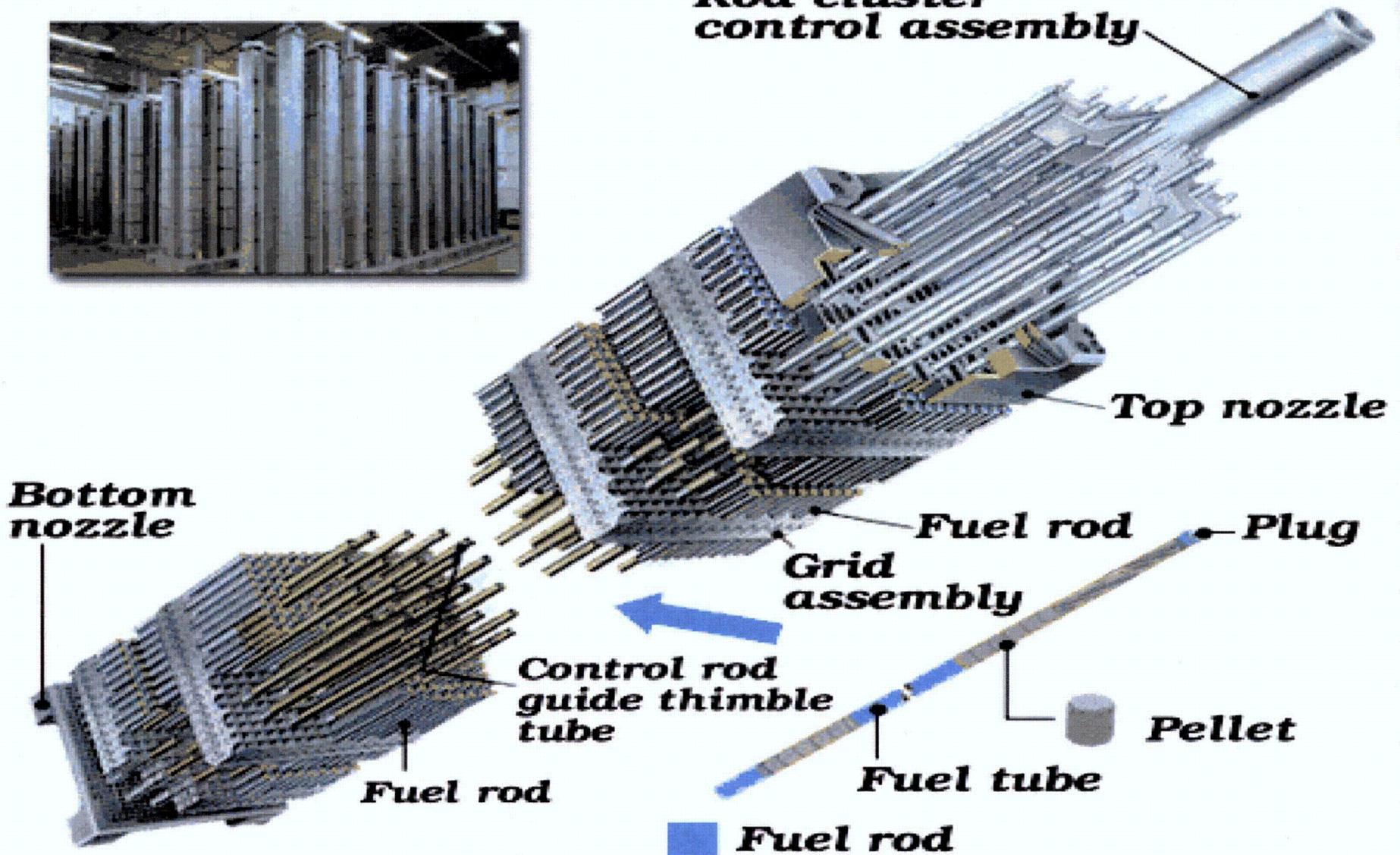
**U.S. NRC**

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### Rod cluster control assembly



# Fuel Rods and Hardware

- Rods

<b>Fuel</b>	<b>Cladding</b>
UO <sub>2</sub>	Zircaloy
MOX	Zr alloys
Metal	Aluminum
UZrHx	Stainless

- Hardware

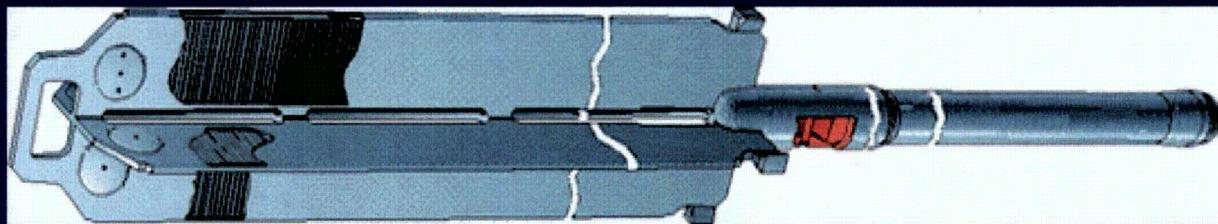
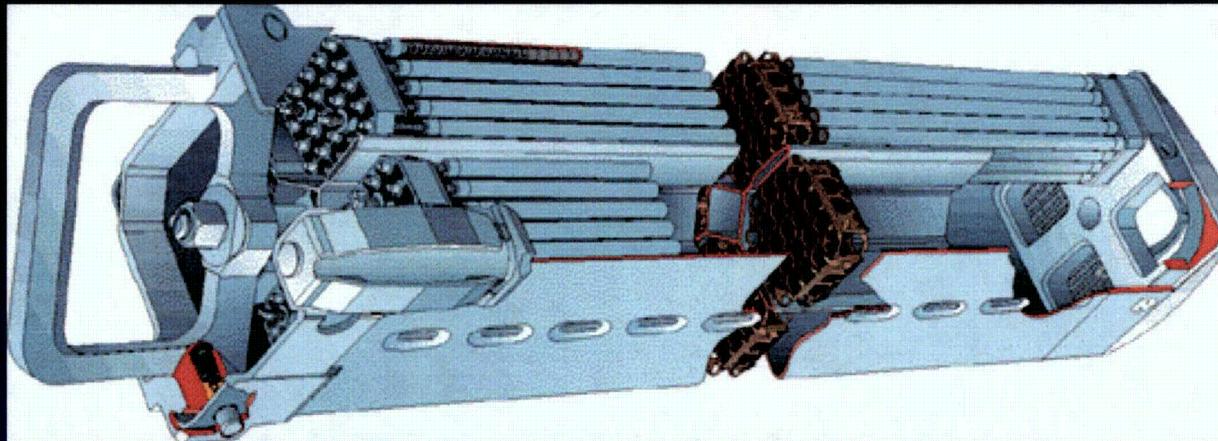
- Springs
- Flow spacers
- End bells
- Water channels
- Control rod tubes
- Wrappers
- Debris filters
- Grid spacers
  - Zircaloy
  - Inconel

# PWR Fuel Characteristics

- 14 x 14                      18 x 18
- 3 manufacturers
- cladding types
- full and partial length rods
- Internal pressure
- Cladding thickness and condition
- Fuel enrichment
- Burnable poison
- Reactor operating conditions

# Reactor Vessel Assembly

## ABB Fuel Assembly and Control Rod



# BWR Fuel Rod Variations

- 6 x 6      10 x 10
- Internal pressure
- Cladding thickness
- Enrichment
- Operating conditions
- Rod arrangement



## Chemical Composition of Zircaloy-2, Zircaloy-4, and Recent Zirconium Alloys in Weight Percent (Zirconium Balance)

Alloy	Tin	Iron	Chromium	Nickel	Niobium	Oxygen
Zircaloy-2	1.2-1.7	0.07-0.20	0.05-0.15	0.03-0.08	—	0.14 max
Zircaloy-4	1.2-1.7	0.18-0.24	0.07-0.13	0.007 max	—	0.14 max
ZIRLO*	0.9-1.2	0.09-0.12	—	—	0.9-1.3	
M5†	0.8-1.2	0.015-0.06	—	—	0.8-1.2	0.09-0.18



## **ZIRLO**

**Modification of Zr-4**

**1% Nb alloy**

**Reduction in Sn and Fe**

**Elimination of Cr**

**75% cold-worked and stress relieved**

**More corrosion resistance than Zr-4**

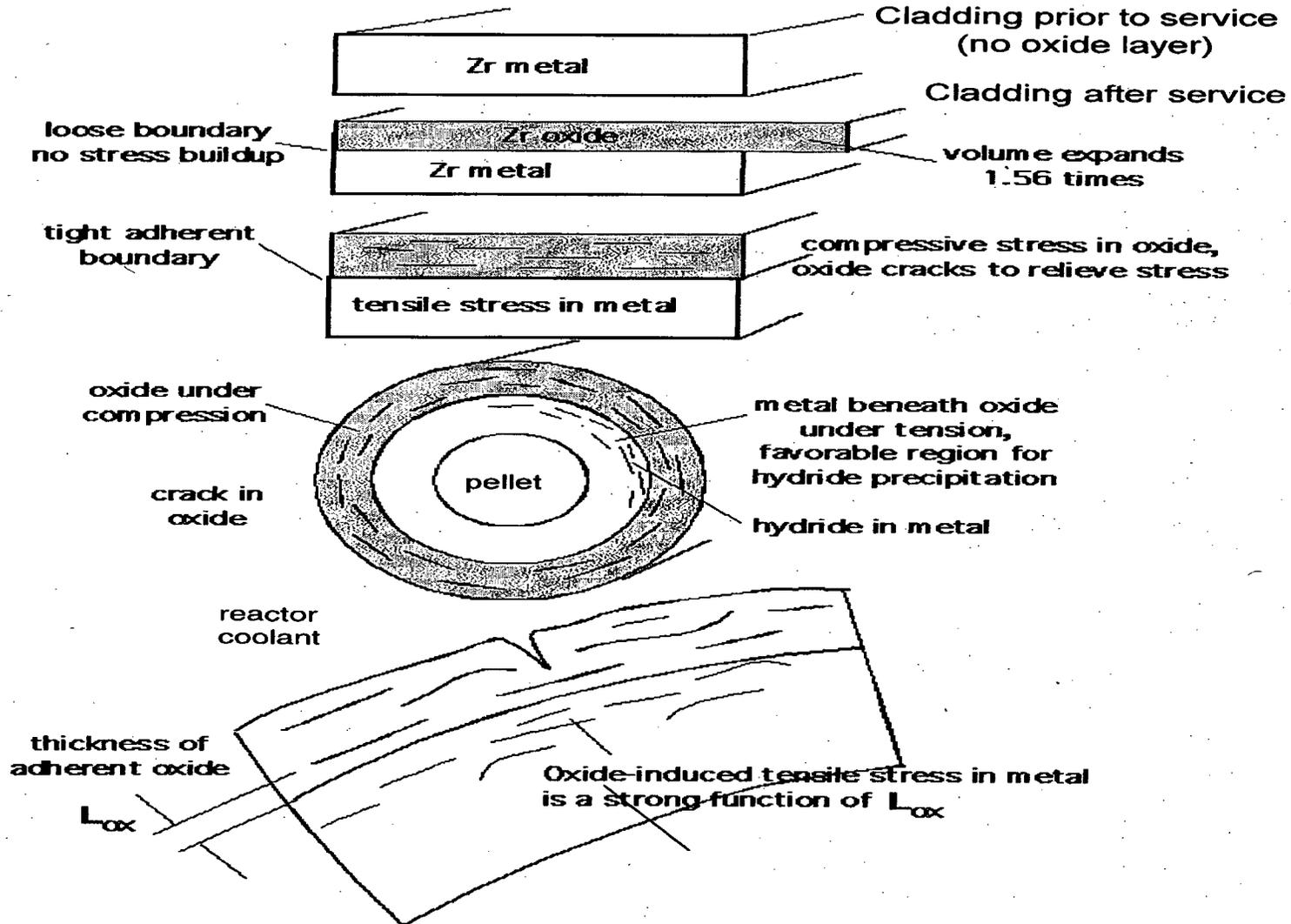
**High duty plants (corrosion levels up to 100 microns)**

**physical properties of ZIRLO are very similar to those of standard Zircaloy-4 clad.**

# Limitation of zirconium alloys

- The absorption of hydrogen
  - brittle zirconium hydrides in the zirconium matrix
  - Under certain conditions of stress, embrittlement of zirconium alloys can be promoted

## Limitation of zirconium alloys



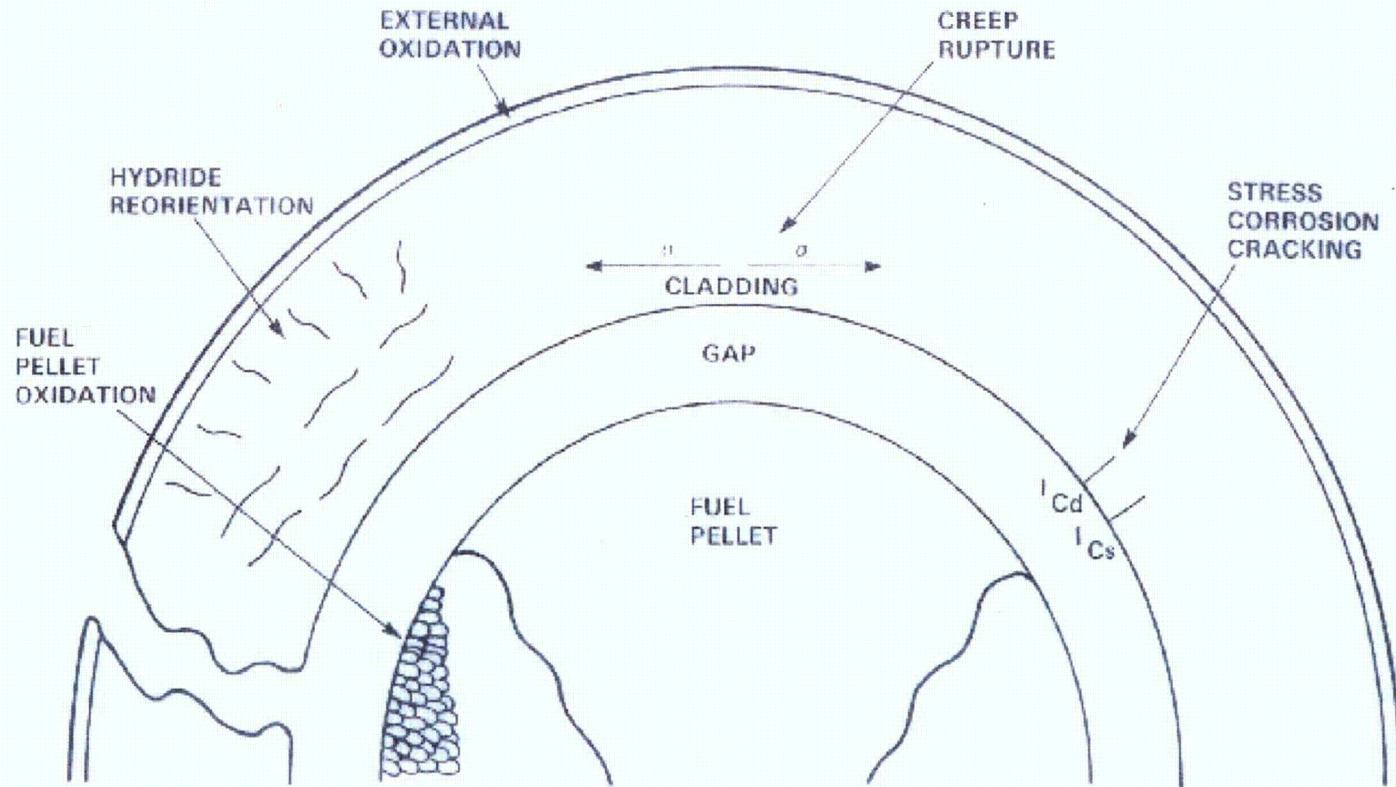
**NOTE:** Oxide-induced residual stress in metal is a function of thickness of uncracked adherent oxide ( $L_{ox}$ ) in contact with metal.

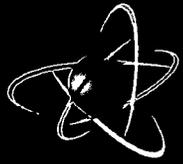


## Degradation Modes of Rod Degradation

- General and localized corrosion,
- Spallation,
- Creep,
- Fuel and cladding oxidation,
- Pellet/cladding interaction failure,
- and Hydride Reorientation

# MODES OF FUEL ROD DEGRADATION

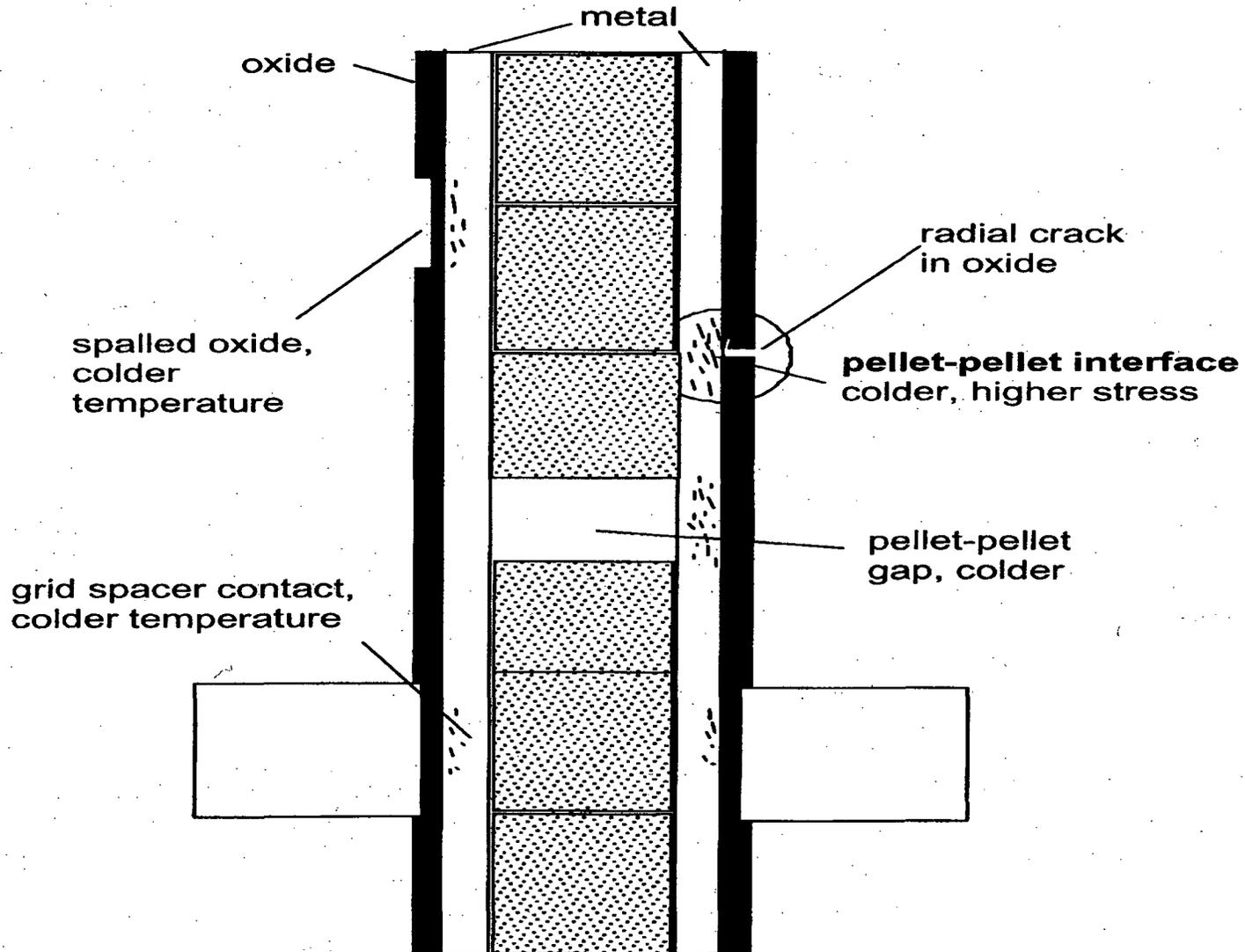




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# Oxidation of Cladding/HBF

- Water-side corrosion
- Zirconium hydrides
- Hydriding increases with the increase in burnup

## **Hydride precipitates are formed in the reactor**

- Generally circumferentially oriented in PWR cladding
- Randomly oriented in BWR cladding

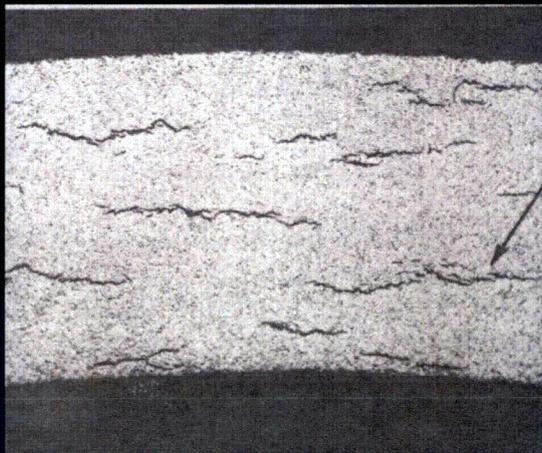
## How are radial hydrides formed

- Hydrides form as the fuel cools in the reactor pool.
- Fuel cladding temperature increases during short-term operations
- High-burnup fuel, hydrogen goes back into solution
- Upon cooling, the hydrides will precipitate in the radial direction

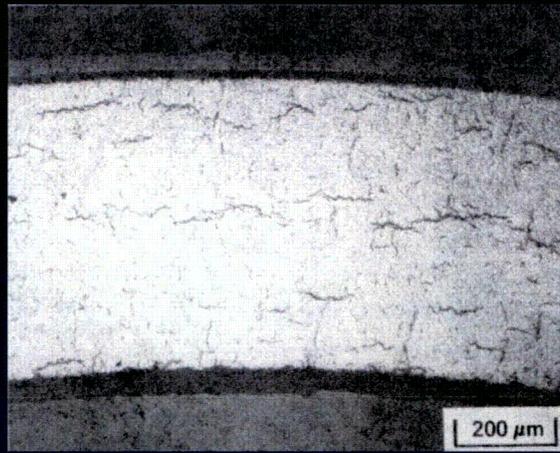
# Hydride Reorientation

- The materials phenomenon of hydride reorientation in zirconium-based alloys usually involves the dissolution of circumferential hydrides and the formation of zirconium-hydrides oriented perpendicular to the hoop stress (also referred to as radially oriented or radial hydrides)

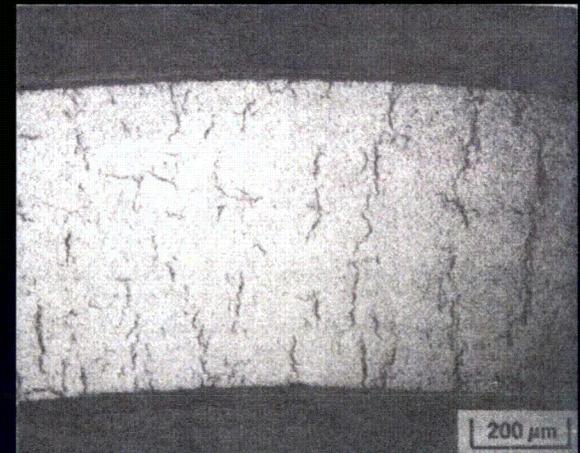
# Hydride Reorientation



**Circumferential  
Hydrides in  
Irradiated Zircaloy  
Cladding**



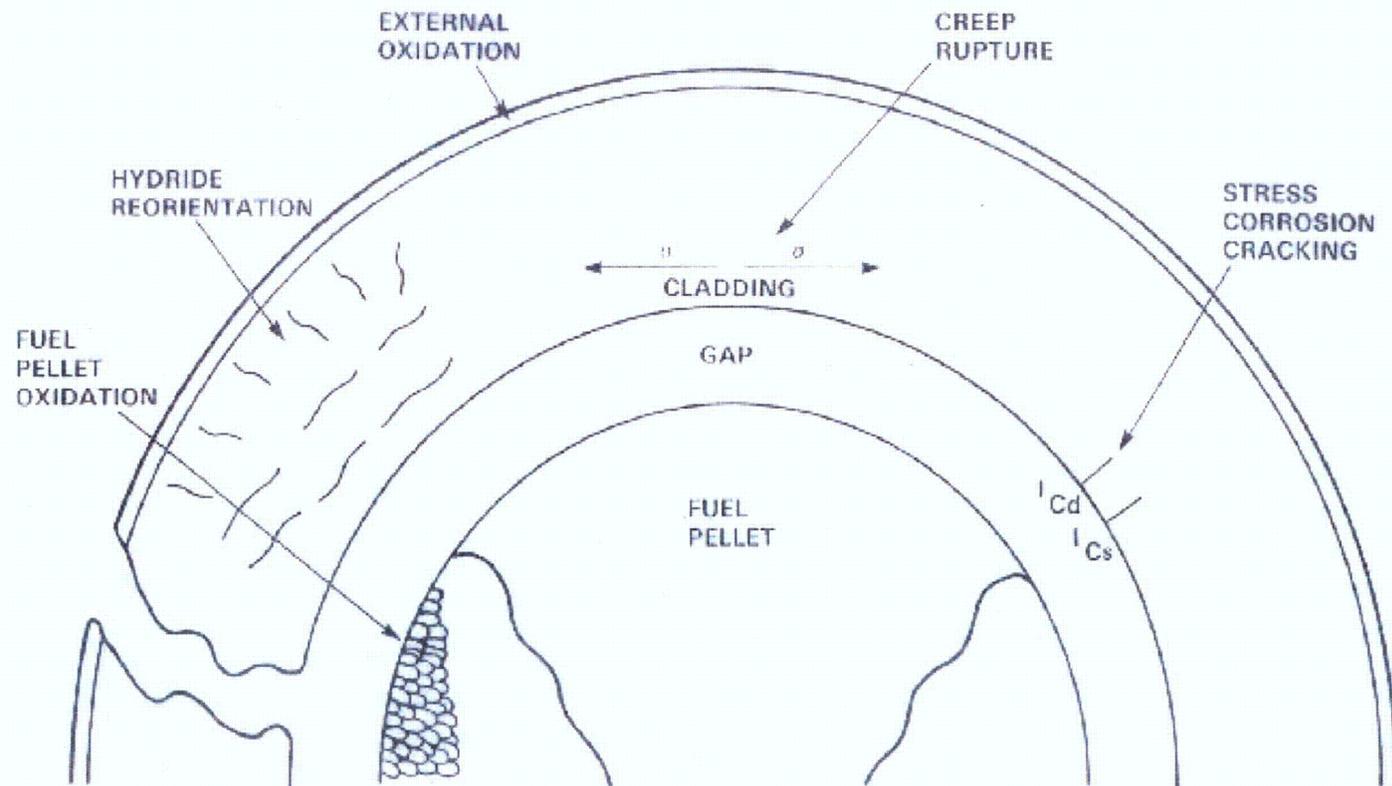
**Mixed Hydrides  
In Irradiated Zircaloy  
Cladding**



**Radial Hydrides  
In Irradiated  
Zircaloy Cladding**

Photographs from *Nuclear Technology*, v. 67 (Oct. 1982) p. 107.

## MODES OF FUEL ROD DEGRADATION





## What is the problem with $\text{UO}_2$ exceeding 45 GWd/MTU

- $\text{UO}_2$  fuel undergoes significant changes
  - chemical composition
  - formation of rim structure.
- These changes become more prominent as the burnup increases
  - pellet cracking
  - pellet swells causing the pellet-cladding gap to close

# Oxidation of Spent Fuel

- Irradiated uranium dioxide exposed to an oxidizing atmosphere will eventually oxidize to  $U_3O_8$
- $UO_2$  to  $U_4O_9$  to  $U_3O_8$
- Fct of Time and Temp
- Induces a circumferential stress in the cladding

# In summary, fuel characteristic changes as burnup increases

	Low	High
<b>Fuel structure</b>		
rim	None	Outer 8-10% of fuel volume has rim structure with submicron grain size
Fuel-cladding gap	Open	May be open or closed dependent on burnup and storage temperature, due to pellet swelling

In summary, fuel characteristic changes as burnup increases

**Low**

**High**

## **Fuel structure**

Grain boundary bubbles

Some bubble structure on grain boundaries

Higher fission gas release indicates more open grain structure

Radionuclide distribution

Open

Excess actinides in the rim region

In summary, fuel characteristic changes as burnup increases

	<b>Low</b>	<b>High</b>
<b>Cladding materials</b>	Zircaloy-4, -2,	M5, ZIRLO, others
<b>Cladding defects</b>	Pinholes, hairlines	More large fretting defects
<b>Cladding composition</b>	<150 wppm hydride	50-700 wppm hydrides