

**NUCLEAR REGULATORY COMMISSION**

ORIGINAL

Title: Advisory Committee on Reactor Safeguards  
Future Plant Designs Subcommittee

Docket Number: (not applicable)

PROCESS USING ADAMS  
TEMPLATE: ACRS/ACNW-005

Location: Rockville, Maryland

Date: Tuesday, January 13, 2004

Work Order No.: NRC-1251

Pages 1-380

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

FUTURE PLANT DESIGNS SUBCOMMITTEE

\* \* \*

MEETING

\* \* \*

ROCKVILLE, MARYLAND

\* \* \*

TUESDAY

JANUARY 13, 2003

\* \* \*

The Subcommittee met in Room 2TB3 at Two White Flint North, 14555 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Thomas S. Kress, Subcommittee Chair, presiding.

PRESENT

- THOMAS S. KRESS, Subcommittee Chair
- GEORGE E. APOSTOLAKIS, ACRS member
- F. PETER FORD, ACRS member
- GRAHAM M. LIETCH, ACRS member
- VICTOR H. RANSOM, ACRS member
- STEPHEN L. ROSEN, ACRS member

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1     PRESENT (Continued):

2             WILLIAM J. SHACK, ACRS member

3             JOHN D. SIEBER, ACRS member

4             GRAHAM B. WALLIS, ACRS member

5     NRC STAFF

6             LAURA DUDES                             NRR

7             BELKYS SOSA                             NRR

8             DON CARLSON                             RES

9             WALTON JENSEN                             NRR

10            STEVEN JONES                             NRR

11            JACK ROSENTHAL                             RES

12            PATRICK SEKERAK                             NRR

13            MARTIN STUTZKE                             NRR

14            EDMUND SULLIVAN                             NRR

15     AECL TECHNOLOGIES

16            JOHN POLCYN

17            PETER BOCZAR

18            PETER CHAN

19            RAJ JAITLEY

20            VINCE LANGMAN

21            MARC LEGER

22            JULLIAN MILLARD

23            DAVID RICHARDS

24            STEPHEN YU

25

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P R O C E E D I N G S

(8:29 a.m.)

CHAIRMAN KRESS: Will the meeting please come to order?

This is a meeting of an ACRS subcommittee on future plant designs.

I am Thomas Kress. I am Chairman of this particular subcommittee. Members in attendance are practically everyone, which is good because that was my request. They included: George Apostolakis, Peter Ford, Graham Lietch, Victor Ransom, Steve Rosen, William Shack, Jack Sieber, and Graham Wallace.

The purpose of this meeting is to discuss the advanced CANDU reactor ACR-700 design features and the related pre-application reviews. The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee.

Medhat El-Zeftawy is the designated federal official for this meeting.

Rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on December 22nd, 2003.

A transcript of the meeting is being kept

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1 and will be made available as stated in the Federal  
2 Register notice. It is requested, therefore, that  
3 speakers, number one, identify themselves, their name  
4 and organization they're with and speak mostly loudly  
5 enough that we can all hear, and be sure to use a  
6 microphone.

7 We have received no written comments or  
8 requests for time to make oral statements from any  
9 members of the public regarding today's meeting.

10 I'd like to point out to the committee  
11 members that this is a briefing and to acquaint us  
12 with the design and safety analysis approach of the  
13 ACR-700. We're not yet dealing in severe accident  
14 space at this meeting, and we don't expect to have a  
15 letter on this at this time.

16 But I'm sure that the AECL Canadian  
17 representatives would be interested if we have any  
18 early concerns. We could get them by voice here, and  
19 they could be then prepared to address them at some  
20 later meeting.

21 I'm not sure if we have any particular  
22 early concerns. My reading of the information we have  
23 so far, which is pretty extensive -- it took quite a  
24 while -- is some of the things we need to do is we  
25 need to look at the codes that they've used and their

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1 status of validation, what experiments they have done.

2 It looks to me like they have a good set  
3 of design basis accidents that are equivalent or even  
4 more stringent than what we have. I like their  
5 defense in depth. It looks very good to me. It looks  
6 like it's as appropriate as ours with the right  
7 diversity and redundancy on key safety tissues.

8 I like their use of what I call FC curves  
9 for acceptance criteria, and they look fully  
10 equivalent to some of our acceptance criteria.  
11 They're mostly in doses and design basis space.

12 I think we have to look at their PRA,  
13 which won't be part of this particular meeting yet,  
14 but maybe in the future. Particularly look to see if  
15 it meets our quality standards for PRAs.

16 I think their "design to" safety goals  
17 meet the U.S. expectations for higher level safety for  
18 advanced reactors. Those are just some of my early,  
19 early impressions of the written material. So I'm not  
20 at all negative about the design. I think there are  
21 some issues that we'll want to discuss and learn more  
22 about. Maybe if members have any, they can express  
23 them either now or later as we go through the meeting.

24 So do I hear any comments from other  
25 members before we get started?

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1 (No response.)

2 CHAIRMAN KRESS: Seeing none, I'll turn to  
3 our agenda for today, which is long and tight, and I  
4 expect I will have to exercise some control over it  
5 this time. So I hope the members understand if I cut  
6 out some debate at this time. I don't want to inhibit  
7 some of our question asking, just some of our debate  
8 back and forth. We can do that later. But ask all  
9 the questions you like.

10 At this time I'd like to move to the  
11 second part of our agenda which is the introductory  
12 comments from the NRC staff, and I presume Laura Dudes  
13 will do that.

14 MS. DUDES: Good morning. I'm Laura  
15 Dudes. I'm the Section Chief for the New Reactors  
16 Group in the Office of Nuclear Reactor Regulation.

17 We are so pleased to come before the ACRS  
18 today to present our approach for the pre-application  
19 review for the ACR-700 reactor design. We consider  
20 this meeting an important step in a process that is  
21 going to take us down quite a few different roads and  
22 challenges in the next year.

23 We intend to discuss today our planned  
24 approach for our technical reviews, our approach to  
25 address regulatory infrastructure needs to a certain

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1 extent, and policy issues that may need to be  
2 communicated to the Commission.

3 I'd like to take this time to actually  
4 welcome AECL Technologies to this first ACRS meeting  
5 and also to acknowledge members of the Canadian  
6 Nuclear Safety Commission who are here today to  
7 observe this meeting as part of our ongoing  
8 international collaboration efforts on this project.

9 Briefly, the pre-application review began  
10 in mid-2002 and was divided into two phases. Phase  
11 one was a design familiarization process in which the  
12 staff participated in several informational meetings  
13 and facility tours in order to gain an understanding  
14 of the overall design and operation of the ACR-700.  
15 Phase one completed in the summer of 2003.

16 Phase two, which we're in now and which  
17 includes presentations to the ACRS as we go through  
18 this, includes the more specific review of the design  
19 features of the ACR-700. Phase two, however, will not  
20 necessarily draw regulatory conclusions on all issues  
21 reviewed during the pre-application phase.

22 The key focus topics that will be reviewed  
23 during phase two have been designated by the  
24 applicant, AECL.

25 The staff is presently in the early stages

1 of their technical review, and our goals here today  
2 are simple. AECL will be presenting an overview of  
3 their design, and the staff hopes to discuss their  
4 technical approach to some of the more challenging  
5 issues and key focus topics; hopefully call out a  
6 process and a plan that we plan to use to approach  
7 regulatory challenges and policy issues that may need  
8 to go to the Commission in the future.

9 Thank you.

10 CHAIRMAN KRESS: I wonder if we could ask  
11 the Canadian safety --

12 MS. DUDES: Members to stand up?

13 CHAIRMAN KRESS: -- members to stand so we  
14 can know who they are.

15 MS. DUDES: Sure.

16 CHAIRMAN KRESS: I'm not sure we're  
17 familiar with all of them.

18 Wow. I won't bother to ask you to  
19 introduce yourself. We're very happy you're here, and  
20 please feel free to take part in any of the debate or  
21 discussion if you'd like.

22 Thank you very much.

23 MS. DUDES: As you can see, our  
24 international collaboration effort is going quite well  
25 on this project.

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1 CHAIRMAN KRESS: Thank you, and with that,  
2 we'll get started with the meat of this meeting and  
3 turn it over to the AECL representatives for their  
4 introductory remarks.

5 MR. POLCYN: Good morning. My name is  
6 John Policy. I'm the President of AECL Technologies,  
7 which is the U.S. subsidiary of AECL. So I'm  
8 responsible for the deployment of the ACR-700 in the  
9 U.S., if you will.

10 Echoing Laura's words, I'd really like to  
11 thank you for the opportunity to come before you this  
12 morning and to talk about the ACR-700 and provide you  
13 an overview,

14 I want to acknowledge, too, Jim Lyons and  
15 Belkys Sosa on the NRC staff and project management  
16 for being so cooperative, so open with us. In terms  
17 of collaboration, we've had a lot of interaction.  
18 We've had visits by staff to our Chalk River  
19 laboratory and our White Shell facility.

20 One thing about the ACR-700. It is based  
21 on proven technology, on the CANDU technology.  
22 There's 34 plants operating, units operating  
23 throughout the world, 22 of which are just north of  
24 the border.

25 I want to acknowledge CNSC as well. We're

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1 kind of running a parallel path right now. We do have  
2 a high level of interest in Ontario for new nuclear  
3 generation. So I think it's very important that we do  
4 work collaboratively.

5 Relative to the U.S., I will tell you that  
6 we do have a couple of very serious customers. So  
7 going back to what Tom said, it's very important that  
8 we understand what issues you have and get those on  
9 the table and discuss them and come to -- you know, at  
10 least develop a road map for resolution of those  
11 issues.

12 We feel like we owe that to our customers  
13 because we certainly don't want to impact their  
14 schedules. We have been included in the envelope of  
15 the three early site permits that have been filed by  
16 Exelon, Intergy, and Dominion, and also continue to  
17 work with other utilities as well that have shown an  
18 interest in the ACR-700.

19 I will tell you that we feel like we're a  
20 little bit unique. We're very open. We have nothing  
21 to hide. We don't have all the answers. We want to  
22 work with you in a very collaborative, open basis,  
23 have a lot of interaction so that we do understand the  
24 issues and concerns and questions so that we can  
25 respond to them or come back to you with the

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1 appropriate answer and with the right people.

2 With that, what I'd like to do is just  
3 take a couple of minutes and introduce our technical  
4 experts that we brought with us today, and I would ask  
5 them to stand so that you can see them so that we  
6 don't have to do a jack-in-the-box and introduce each  
7 one individually as they come up.

8 I'll be turning this over to Stephen Yu,  
9 who's our program manager for the ACR product  
10 development. He's going to provide an overview of the  
11 ACR and its key features.

12 Following Stephen will be Vince Langman.  
13 Vince is our ACR design certification program manager.  
14 He'll review our pre-application scope and  
15 expectations from the staff and talk about the  
16 feedback from the pre-application program which is key  
17 to the continuation of our certification and future  
18 licensing resource expenditures here in the U.S.

19 Vince will be followed by Mar, Leger,  
20 who's the Director of Materials Engineering. He'll  
21 discuss the unique design of the ACR pressure tubes  
22 and fuel channels, and when I say unique, you'll see  
23 design features that are not incorporated into any  
24 PWRs or BWRs, but they're absolutely integral to the  
25 horizontal core and operational philosophy.

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1           And I will remind everybody that we do  
2 consider the ACR-700 as a light water reactor that  
3 happens to use heavy water simply for moderation.

4           Following Mark will be Dave Richards, who  
5 is the manager of AECL Code Center and Software  
6 Performance. He'll discuss our computer code  
7 development and qualification, and as you'll hear in  
8 Vince's presentation, AECL has acknowledged that our  
9 computer software quality will be one of the key focus  
10 topics from the staff's review. So Dave will be able  
11 to address those concerns, those questions.

12           Following Dave will be Jullian Millard.  
13 He's our manager of ACR reactor and fuel handling who  
14 will discuss our on power fueling. This is another  
15 feature that's absolutely integral to the ACR, and  
16 that it makes possible the use of SEU and allows us to  
17 reach the high capacity fractures that our U.S.  
18 utility customers and worldwide customers have made  
19 the requirement.

20           Following Jullian will be Peter Chan.  
21 Peter is our team leader for ACR physics and fuel.  
22 He'll discuss a topic that has been of high interest  
23 to everyone, and that's negative void coefficient.  
24 That was the subject of much interest in the CANDU-3  
25 days.

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1                   Following Peter will be Peter Boczar.  
2                   Peter is our Director of Reactor Core Technology, and  
3                   he will provide a more detailed description of the ACR  
4                   fuel design, and ACR fuel being another design feature  
5                   that substantially departs from PWR and BWR concepts  
6                   here in the U.S.

7                   And then lastly, Raj Jaitly, who's our  
8                   manager of PSA and safety design, will discuss AECL's  
9                   PRA methodology that we intend to use to design and  
10                  evaluate the ACR on an ongoing basis.

11                  And with that, I'll turn the program over  
12                  to Stephen Yu, who will give you a design overview of  
13                  the ACR.

14                  Thank you.

15                  MR. YU: I guess I will first sit down so  
16                  that you can see the screen.

17                  DR. WALLIS: That's the first test.

18                  MR. YU: That's the first one.

19                  CHAIRMAN KRESS: Why don't you hook up the  
20                  portable one to him?

21                  MR. YU: Good morning. In terms of the  
22                  initial talk, it's to give an overview so that later  
23                  on in the morning when they provide the discuss on the  
24                  focus topic so that you know in what relationship to  
25                  the rest of the main features of the ACR design.

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1 I am in charge of a team that has been  
2 working on this for the last two and a half years now.  
3 The team is made up of NSPHN group (phonetic), plus  
4 the safety and licensing group, and so we have  
5 proceeded and defined the concept. We're now very  
6 much working plus the detail so that we will be able  
7 to put together a design control document for later  
8 submission on design certification.

9 So our work is nowhere complete, but we  
10 certainly have defined a lot of the design features  
11 that we are going to use. So there's still some  
12 optimization that's going on, which when we delve into  
13 details, some of the design details are being evolved  
14 taking into consideration of some of the initial  
15 feedback from the review as well as from  
16 constructability, operational feedback. We are  
17 incorporating some further design changes into them.

18 So the other item in my talk is mainly on  
19 the general design features like the fuel, which you  
20 will hear more about.

21 DR. WALLIS: I'm interested. How do you  
22 optimize the design? You've got various criteria for  
23 optimization, one of which is economics and one of  
24 which is safety. How do you trade these off in an  
25 optimization of a design?

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1 MR. YU: Certainly the basic safety  
2 principles of ACR is inherently in the traditional way  
3 that we have done our safety criteria. We are  
4 following the regulatory guide that has been  
5 established for the design principles.

6 Certainly when you are trading off CANDU  
7 design features which are operational features, that's  
8 no different than what we have always been doing as  
9 to, you know, how much complexity do you introduce  
10 versus, you know, that how to simplify the design so  
11 that it's easier for it to operate.

12 Cost is certainly a consideration. A lot  
13 of them that we are looking at a specific cost target.  
14 Other pieces in the different parts of the plant.  
15 Certainly safety is paramount. We need to be able to  
16 make sure that we meet the safety acceptance criteria  
17 with margins.

18 DR. WALLIS: So they're a constraint.  
19 They're not part of the optimization costs?

20 MR. YU: They are the constraints that we  
21 need to meet, yes.

22 DR. APOSTOLAKIS: Did you also include, in  
23 addition to cost and safety, any of the other  
24 objectives that have been articulated by the  
25 Department of Energy for future reactors or you don't

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1 consider this a future reactor, like sustainability,  
2 security, and so on?

3 MR. YU: We look at in the GEN-4  
4 studies --

5 DR. APOSTOLAKIS: Yes.

6 MR. YU: -- essentially we are looking at  
7 accessibility in terms of fuel cycles, in terms of the  
8 ability of CANDU to be able to burn different  
9 materials, and certainly we are looking at our  
10 features so to make sure that it's able to carry  
11 through.

12 I think certainly our change to light  
13 water coolant, as well as certain enriched uranium  
14 fuel, which is really a step in the direction that  
15 we'll be able to use MOX fuel and other fuel cycles.  
16 And that, in terms of your end utilization and so on,  
17 that would be an objective in the very beginning set  
18 in the concept.

19 But the details is really we take an  
20 evolutionary step, making some radical changes  
21 initially for the design concept, and then stick with  
22 that and proceed with the design by itself.

23 DR. APOSTOLAKIS: So these other  
24 objectives are sort of secondary here?

25 MR. YU: We want to make sure that we can

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1 move in that direction, but not essentially trying to  
2 optimize it for that at this point in time, but we are  
3 looking at major obstacles that might prevent us.  
4 Then we will look again.

5 So on to highlight some of the engineering  
6 safety features because that will be a key element of  
7 the safety design. I want to give a brief  
8 introduction of an approach in the severe accident  
9 features and the mitigation. This is a big subject.  
10 So I'm only touching the surface in this overview, and  
11 also some of the operational features in the design  
12 itself.

13 In terms of ACRS, I mentioned that we are  
14 doing an evolutionary extension of our CANDU 6 plant.  
15 The picture that you see are the two 600 megawatt  
16 design that's now operating in China, which is the  
17 latest version of the CANDU 6 design that we have.

18 We still have one unit under construction  
19 in Romania.

20 When we talk about the core of the design,  
21 this is the calandria, which is the equivalent of the  
22 reactor core vessel, but the calandria is really a low  
23 pressure vessel, and it contains the moderator, while  
24 you see the entity coming off on the ends. This is  
25 really the connection to the pressure tube within the

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1 reactor itself, and that's where the other connections  
2 to the reactor cooling system.

3 CHAIRMAN KRESS: I would have called the  
4 calandria -- I wouldn't have called it part of the  
5 reactor coolant pressure equivalent. I would have  
6 called the pressure tubes the equivalent of the  
7 reactor vessel.

8 MR. YU: The pressure tube would be the  
9 equivalent of the reactor vessel.

10 CHAIRMAN KRESS: Yeah, I thought you said  
11 the calandria was. I wouldn't have said that I don't  
12 believe

13 MR. YU: Thank you.

14 CHAIRMAN KRESS: So are we looking at the  
15 ends that would be connected to the refueling machine  
16 when we look at that picture?

17 MR. YU: Yes. As you can see here that  
18 the fueling machine would be connected to the ends of  
19 the fuel channel where the inputting and then  
20 connected to the pressure tube.

21 DR. ROSEN: The calandria operates at what  
22 pressure normally?

23 MR. YU: It operates at around 30 PSI.

24 CHAIRMAN KRESS: The refueling machines on  
25 each end become part of the reactor coolant system.

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1 MR. YU: When it is connected to the  
2 reactor coolant system, yes, it forms the extension to  
3 the reactor cooling pressure.

4 MR. SIEBER: And the pressure there is  
5 about 2,000 pounds per square inch.

6 MR. YU: That is government (phonetic).

7 MR. SIEBER: Roughly, yeah.

8 DR. ROSEN: And you analyze loss of  
9 coolant accidents with the refueling machine in place  
10 and without?

11 MR. YU: The additional volumes in the  
12 refueling machine is such a small volume. So in terms  
13 of sterilize safety analysis, I don't think it's going  
14 to impact it.

15 Would they be assessed, Victor?

16 MR. SNELL: You analyze breaks in every --  
17 I'm sorry. I'm Victor Snell, Director of Safety and  
18 Licensing for the ACR Project.

19 We analyze breaks in every pipe in the  
20 reactor coolant system. We analyze breaks which are  
21 initiated by the fueling machine, but if the fuel  
22 mission is on reactor and a break in another pipe  
23 occurs, as Stephen says, that role is not very  
24 important. What is important is whether the fueling  
25 machine actually can initiate a breach in the

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1 boundary, and that's part of the design basis. What  
2 is important is whether the fueling machine actually  
3 can initiate a breach in the boundary, and that's part  
4 of the design basis.

5 DR. ROSEN: Well, I was thinking more  
6 about whether the fueling machine can interact with a  
7 tube that fails while it happens to be on that tube  
8 and whether the effects of that interaction during a  
9 failure of the pressure tube or perhaps the end  
10 fitting has been analyzed.

11 MR. SNELL: We bound that by assuming one  
12 of the design basis accidents, assuming the fueling  
13 machine for some reasons backs off the channel without  
14 closing it.

15 DR. ROSEN: But then it would restrict the  
16 flow somewhat.

17 MR. SNELL: Well, the ejected containment.

18 CHAIRMAN KRESS: In your safety analysis,  
19 do you assume more than one pressure tube fails at a  
20 given time?

21 MR. SNELL: No. In fact, it's fundamental  
22 to the design that the pressure fuel failure must not  
23 propagate. It's fundamental to the pressure tube  
24 design.

25 CHAIRMAN KRESS: That's a design

1 objective.

2 MR. SNELL: It's a design requirement.

3 CHAIRMAN KRESS: It's not the biggest pipe  
4 anyway, is it? Your headers are bigger.

5 MR. SNELL: Yeah, the pressure tube is  
6 about that big around.

7 CHAIRMAN KRESS: And the headers are --

8 MR. SNELL: The headers are about eight  
9 inches.

10 CHAIRMAN KRESS: Okay.

11 MR. YU: The inlet, 20 inches; the outlet,  
12 22 inches in diameter. So that really forms the  
13 biggest piping in the reactor coolant system.

14 DR. WALLIS: It looks beautifully simple  
15 until you put in all of the feeder tubes.

16 MR. SIEBER: Yeah.

17 (Laughter.)

18 MR. YU: Well, we do have quite a bit of  
19 connections.

20 So that's part of the optimization I did  
21 talk about. A change from natural uranium fuel with  
22 heavy water coolant and heavy water moderator in  
23 previous operating CANDU reactors to the use of light  
24 water as the coolant; I guess by virtue of that and  
25 the use of the enriched uranium that give us more fuel

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1 cycle flexibility, and also it does change the core  
2 size so that you can make it more compact, and the  
3 others that we are looking at similar designs,  
4 especially in the reactor coolant system that are  
5 operating at higher pressures and temperatures that  
6 give us a better efficiency.

7 And so that's what we have followed, the  
8 trend. And I think our operating pressures and  
9 temperature are still lower than the PWR, but the  
10 rest of the intrinsic CANDU features are retained.

11 So in terms of design features, Peter  
12 Boczar will give you more details on the fuel, but I  
13 think the characteristics of our fuel design has been,  
14 you know the half a meter long bundle and also our  
15 ability to change the fuel on power so that the two  
16 fueling machines are there to replace the fuel when  
17 the rich is burned up.

18 CHAIRMAN KRESS: You have several of these  
19 1.6 foot long bundles in a tube. When they meet up  
20 with each other, is there any requirement that they  
21 meet up in a certain way?

22 MR. YU: No, because we have done all of  
23 our pressure job correlations, both totally in line as  
24 well as --

25 CHAIRMAN KRESS: As much off line as you

1 can get?

2 MR. YU: Yes.

3 CHAIRMAN KRESS: Okay.

4 MR. YU: So --

5 CHAIRMAN KRESS: So it doesn't matter how  
6 they meet.

7 MR. YU: That's right.

8 CHAIRMAN KRESS: This going to light water  
9 coolant and the increasing enrichment is an effective  
10 way, in my mind, to get rid of the negative void  
11 coefficient, the positive void coefficient. Did you  
12 get of it altogether?

13 MR. YU: Yes. That's one of our design  
14 requirements, is to have the negative void reactivity.

15 CHAIRMAN KRESS: Dysprosium in your second  
16 bullet there, is that a burnable poison?

17 MR. YU: It is a burnable poison, yes.  
18 It's one that we have quite a bit of experience in, in  
19 both using NRU and in some of the other experimental  
20 fuels that we have.

21 DR. ROSEN: Can you compare it for me with  
22 samarium?

23 MR. YU: I have to ask Peter to help me.  
24 Peter Boczar.

25 MR. BOCZAR: Peter Boczar, ACL.

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1                   We chose dysprosium because its burnout  
2 characteristics matched the reactivity characteristics  
3 that were required for the ACR, and it was a naturally  
4 occurring fission product. So it turns out it is very  
5 compatible with the fuel.

6                   DR. ROSEN: But samarium is more typically  
7 used than burnable poison, and so I'm just wondering  
8 why.

9                   MR. BOCZAR: We considered a whole range  
10 of burnable poison, samarium, gadolinium, erbium, and  
11 this was the one that best matched the reactivity  
12 characteristics we needed for the ACR.

13                   DR. WALLIS: You have no boron in the  
14 coolant?

15                   MR. YU: No.

16                   DR. WALLIS: So it's harder to detect  
17 leaks then?

18                   (Laughter.)

19                   CHAIRMAN KRESS: That's an inside thing.

20                   MR. SIEBER: That's sort of a relative  
21 thing.

22                   MR. YU: So further on the fuel, burn-up  
23 is around 21,000 megawatt days per ton. This is  
24 certainly about three times our current net uranium  
25 fuel burned up, although it's still much lower than

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1 the PWR fuel burn-up.

2 CHAIRMAN KRESS: Is there any limit in  
3 terms of core neutronics on what burn-up you could go  
4 to?

5 MR. YU: I don't think there's any limit  
6 in terms of core neutronics' viewpoint. I think, you  
7 know, that we want to have the more optimized uranium  
8 utilization, and that's how we arrived at it.  
9 Certainly it is the thoughts for the future we will be  
10 able to increase the burn-up of the fuel by adjusting  
11 the enrichment grading in the fuel bundles itself.

12 So this would allow also to get to, say,  
13 higher bundle power and lower rating than the current  
14 CANDUs.

15 MR. LEITCH: Did I understand you to say  
16 that there were 12 fuel bundles in a pressure tube; is  
17 that correct?

18 MR. YU: There are 12 fuel bundles in each  
19 channel, yes.

20 MR. LEITCH: Then I don't know if later  
21 we're going to discuss the fuel cycle. In other  
22 words, my question, when you get to the on-line  
23 refueling, do you change out all 12 or is there some  
24 kind of a stagger that is in effect there?

25 MR. YU: Certainly, you know, we will be

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1 giving more details on that.

2 MR. LEITCH: Okay.

3 MR. YU: But we will be changing, you  
4 know, the two bundles from the front end, and then it  
5 will be moving progressively downward. So we're  
6 taking it from one end and putting the fuel bundles on  
7 one end.

8 MR. LEITCH: Okay. Thank you.

9 MR. YU: We have been looking at, you  
10 know, the different fuel replacement in the  
11 traditional operating CANDU. We have four bundle  
12 chips as well as eight bundle chips for the actual  
13 uranium, but for here, given the longer burn-up, so we  
14 are reducing the number of bundles that we need to  
15 replace each time because the rest in time in the core  
16 can be longer.

17 CHAIRMAN KRESS: Your clad, is it Zirlo?

18 MR. YU: The clad is Zircaloy, yes.

19 MR. LEITCH: So you're looking at two  
20 bundle shifts now?

21 MR. YU: Current reference, yes.

22 MR. LEITCH: So I think that's the direct  
23 answer to your question.

24 MR. YU: Two bundles, yes.

25 MR. LEITCH: Technically two of the 12

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1 would be moved out.

2 MR. YU: Yes, that's right. We moved the  
3 higher burn-up one from the inner channel and then put  
4 new fuel in the front.

5 MR. SIEBER: That gives you a power peak  
6 toward one end of the reactor.

7 MR. YU: No, because our channels are  
8 oriented such so that one-half the core on alternate  
9 channel. You have the inlet going on one end, and the  
10 addition channel is at the outlet on the other end.  
11 So it does balance out.

12 MR. SIEBER: So each refueling machine can  
13 operate either as an inlet or an outlet machine?

14 MR. YU: That's correct, yes.

15 MR. SIEBER: All right.

16 MR. YU: It has the flexibility to be able  
17 to do that.

18 CHAIRMAN KRESS: How do you know? How are  
19 you able to decide which one of your fuel elements is  
20 defective if you're leaking fission products?

21 MR. YU: There is an overall detection  
22 knowing that there will be activity in the core, and  
23 then the fueling machine would be able to be located  
24 on the channels. It would be able to sample --

25 CHAIRMAN KRESS: Oh, you can sample from

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1 any channel?

2 MR. YU: -- groups of channels or  
3 individual channels so that where --

4 CHAIRMAN KRESS: And so you can then  
5 narrow it down.

6 MR. YU: You narrow it down.

7 DR. ROSEN: Sample the coolant flow, yeah?

8 MR. YU: Sample the coolant flow.

9 DR. ROSEN: The outlet coolant flow.

10 MR. YU: Yes.

11 DR. FORD: In one of the articles I was  
12 reading, you would know this within two minutes, was  
13 the metric I heard. You can do this all in two  
14 minutes? Determine whether you have a leak in a tube  
15 within two minutes?

16 MR. SIEBER: Yeah.

17 DR. FORD: Is that right?

18 MR. YU: The leak in the tube, that's  
19 different from the fuel detection.

20 MR. SIEBER: Right.

21 MR. YU: And, yes, I think we're talking  
22 about a feature where we monitor the gas space in  
23 between the pressure tube and the calandria tube. I  
24 think I will be moving towards that.

25 By monitoring the gas space to detect

1 moisture, we'll be able to know whether there's any  
2 leak started in any of the --

3 DR. FORD: Okay.

4 MR. YU: So starting with shorter bundles  
5 it limits the amount of activity that contains noble  
6 gas within the bundles itself, and the clad of  
7 collapsible under the pressure of the reactor coolant  
8 system so as to enhance the heat transfer.

9 Also, because of the relatively low burn-  
10 up, obviously the internal pressure period should be  
11 small, and on the other hand, the fuel design is such  
12 that you look at the gas space allowance from within  
13 the pallet itself, between the clad and the pellet.

14 CHAIRMAN KRESS: How thick is your clad?

15 MR. YU: The clad? Peter? I

16 I don't know.

17 MR. BOCZAR: I'll give the answer when I  
18 give my presentation.

19 MR. LANGMAN: Vince Langman. It's the  
20 thicker clad, right? Yeah, I take it back.

21 CHAIRMAN KRESS: One reason for the  
22 question is I was wondering when you get the design  
23 basis space you have this requirement in our  
24 regulations that you can only oxidize a certain depth  
25 of the clad, but that's the U.S. fuel, and with its

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1 clad thickness and its type of clad, and I was just  
2 wondering how you'd -- I guess we'll get to that  
3 later, but how you deal with that issue if you have a  
4 different kind of clad thickness.

5 MR. LANGMAN: Right.

6 DR. SHACK: Have you changed cladding as  
7 you've changed cladding as you've gone from the CANDU  
8 6 to the ACR?

9 MR. YU: No, it's immaterial.

10 DR. SHACK: It's Zirc-4 in both of them  
11 for the fuel clad?

12 MR. YU: Yes.

13 In the few channel design, it's where you  
14 can see this is the exact dimensions of a scale model  
15 of the pressure tube, which is the reactor coolant  
16 pressure boundary within the core and the calandria  
17 tube. The inner scarce space is where we monitor  
18 moisture. Normally we circulate through them.

19 CHAIRMAN KRESS: How did you decide on CO<sub>2</sub>  
20 in there? I was wondering perhaps why not --

21 MR. YU: Well, in earlier reactor design  
22 we had gone for nitrogen, but I think the isotopes  
23 that came out is not good. So coming to outside give  
24 us the best response. In terms of inner gas for  
25 insulation --

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1 CHAIRMAN KRESS: Well, I guess helium  
2 would have a bad isotope, too, that you couldn't  
3 follow.

4 MR. SIEBER: Yeah.

5 CHAIRMAN KRESS: Okay.

6 DR. FORD: There's a whole range of  
7 materials degradation modes inherent in this graph,  
8 and this very sort of qualitative statements that have  
9 been made here, will those be covered later on as to  
10 the quantification of some of these items here and how  
11 that affects the kinetics of materials degradation?

12 MR. YU: Mark, can you answer whether  
13 they're going to be addressed further?

14 MR. LEGER: Mark Leger.

15 We will be addressing some of those  
16 degradation issues in the pressure tube presentation.

17 DR. FORD: Good.

18 CHAIRMAN KRESS: The only one you've  
19 observed so far has been erosion-corrosion?

20 MR. LEGER: No, in pressure tubes we don't  
21 see any erosion-corrosion.

22 CHAIRMAN KRESS: At the inlets?

23 MR. LEGER: At either end.

24 CHAIRMAN KRESS: Either end? I thought I  
25 read that somewhere.

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1 MR. LEGER: We have had flow accelerated  
2 corrosion in --

3 CHAIRMAN KRESS: That's what I ready.

4 MR. LEGER: -- in other parts of the  
5 system.

6 CHAIRMAN KRESS: Yeah. Are these  
7 calandria in pressure tubes -- they're in a pretty  
8 high neutron fluence field. Are they subject to  
9 imbrittlement or will we discuss that later?

10 MR. YU: That will be part of the  
11 environment operating, yes, described further.

12 MR. SIEBER: I take the replacement tubes  
13 are replaceable then.

14 MR. YU: That's correct.

15 MR. SIEBER: All right.

16 MR. YU: And actually in current operating  
17 reactors, we have also replaced in some of the  
18 refurbishment projects we are also planning in some  
19 cases being able to replace the calandria tube as well  
20 if it needs be. But those are operating under low  
21 pressures anyway.

22 That is the relative comparison of the  
23 kind of changes that we have made and also the CANFLEX  
24 bundle with two different pin sizes. The bigger pin  
25 size is similar to what we have used before, but this

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1 is a smaller pin size which contains two rings in the  
2 CANFLEX bundle. This is what we have used in the ACR.

3 These fuel bundles have gone through  
4 reactor irradiation in one of the CANDU 6, despite the  
5 fact that it was using lesser uranium, but a lot of  
6 the elements have gone through lots of research  
7 environments to look at its performance and its  
8 behavior under different operating conditions.

9 CHAIRMAN KRESS: Have you subjected these  
10 to heat transfer tests to look at distribution of  
11 temperatures around the --

12 MR. YU: Yes, very much so.

13 CHAIRMAN KRESS: We ought to hear about  
14 that later maybe?

15 MR. YU: Yes.

16 CHAIRMAN KRESS: Maybe not this meeting  
17 but later-later maybe?

18 MR. YU: I think it will give you some  
19 high level view even at this meeting in terms of the  
20 measurements under, you know, the transient  
21 conditions. So the gap that I talk about, this larger  
22 gap as well.

23 DR. RANSOM: What is the pressure in the  
24 gap, the CO<sub>2</sub>?

25 MR. YU: The pressure in the gap is

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1 typically we just press around 30 psi as well, the  
2 celulor (phonetic). We just have it enough so that  
3 you would be able to circulate it using compressors  
4 around the different ends.

5 DR. RANSOM: So it's about the same  
6 pressure as the calandria then?

7 MR. YU: Yes. The operating pressure is  
8 about 10 psi. So it is within that design envelope,  
9 yes.

10 DR. ROSEN: And the eight internal rods  
11 are the only ones that contain the burnable poison; is  
12 that correct?

13 MR. YU: That's correct. The center rod  
14 is the only one that contained it.

15 DR. ROSEN: Only the center rod?

16 MR. YU: Only the center rod.

17 DR. ROSEN: Not the others of the -- any  
18 other rod in the bundle.

19 MR. YU: No. Only the center rod has the  
20 burnable poison. All the others just have the  
21 enriched uranium.

22 That gives you the range of operating  
23 pressures and temperature that we use in ACR. As I  
24 indicated, we extended our operating range to study  
25 higher, between 13.2 megapascal in the inlets of the

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1 pressure tube, while it's around 12 megapascal at the  
2 outlet pressure tube. Certainly when you have this  
3 (unintelligible) depending on where the pressure tube  
4 is located between the region.

5 Core (unintelligible) is around 2.5  
6 millimeters thick. The diameter is around six inches.

7 MR. SIEBER: What is the peak clad  
8 temperature in normal operation at 100 percent power  
9 under these hydraulic parameters?

10 MR. YU: Normal operating peak clad  
11 temperature. Peter, can you please answer?

12 MR. BOCZAR: Peak clad temperature would  
13 be slightly above the coolant temperature.

14 MR. SIEBER: Okay. But we're really  
15 talking just a few degrees, right?

16 MR. YU: Yeah, normally it would be just  
17 a few degrees.

18 MR. BOCZAR: Yeah, Peter Boczar, ACL.

19 Peak clad temperature would normally be a  
20 few degrees higher than the peak coolant temperature.

21 MR. SIEBER: And you don't operate in a  
22 boiling position at all, right, or do you allow  
23 nucleate boiling?

24 MR. YU: We do allow boiling towards the  
25 end of the term.

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1 MR. SIEBER: Okay.

2 MR. YU: And actually, our design  
3 condition is to have two percent quality at the outlet  
4 header, and so at the end of the channel, the last  
5 bundle, maybe a bundle and a half depending on channel  
6 power, would have some nucleate boiling.

7 DR. WALLIS: How is the power distribution  
8 across the channel? When you have this moderator on  
9 the outside and then you have slow neutrons coming in  
10 from the moderator, what's the difference between,  
11 say, the power per unit length of the center rod and  
12 the peripheral rods?

13 MR. YU: I think you can see a lot more of  
14 the details in the --

15 DR. WALLIS: We're going to see that later  
16 on?

17 MR. YU: -- in subsequent presentations

18 DR. FORD: You said at the end of the  
19 channel you do have some boiling. Obviously you  
20 haven't talked about the chemistry of the primary side  
21 here yet. We'll be discussing that and the impact of  
22 that if you have boiling?

23 Do you understand the question?

24 MR. YU: Yes, I understand the question.

25 I think we didn't plan to get into the chemistry, in

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1 fact, for the reactor cooling system, but certainly  
2 the boiling impact on the fuel design on the heat  
3 transfer on the CHF, yes, it would be addressed.

4 DR. FORD: Okay.

5 DR. ROSEN: And the safety impact of the  
6 collapse of those voids under certain circumstances?

7 MR. YU: That's taking into consideration  
8 in the safety analysis.

9 DR. ROSEN: We'll hear more about that,  
10 too?

11 MR. YU: Victor, can you come?

12 MR. SNELL: I'm not sure you'll hear more  
13 about it -- this is Victor Snell -- I'm not sure  
14 you'll hear more about it at this meeting, but I'll  
15 give you a thumbnail answer, which is that we've kept  
16 the negative void reactivity fairly small in absolute  
17 terms for safety reasons. So actually the design  
18 center value is minus seven milli-K.

19 The amount of void in normal operation is  
20 a very small fraction of that. There's not much  
21 boiling in the channels. So collapse of void in all  
22 operation has relatively small effect.

23 DR. ROSEN: Relative to the 7 MK?

24 MR. SNELL: Yes.

25 DR. ROSEN: What would you say? One

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1 percent, ten percent?

2 MR. SNELL: I think it's about a milli-K  
3 or something to that. At most a milli-K. Peter?

4 Yeah, Peter is nodding. So it's about --

5 DR. ROSEN: So that would result in a  
6 positive reactivity insertion on void collapse of  
7 about one milli-K.

8 MR. SNELL: That's correct.

9 MR. YU: In terms of fuel channel, this  
10 gives you some more details of the end of the fuel  
11 channel itself. This is where the pressure tube rode  
12 (phonetic) into the end fitting, and we have two tube  
13 sheets in between. That's where the shooting for the  
14 end SEU (phonetic), and shooting for the surrounding  
15 is done by shooting water itself. So the end fitting  
16 is kind of anchored down onto the tube sheet using the  
17 positioning assembly.

18 In order to give the flexibility, the  
19 endless bellows is one that contains the gas boundary  
20 so that we would be able to give it the flexibility on  
21 relative thermal expansion, as well.

22 The connection to the reactor coolant  
23 system is through the what we call a feeder  
24 connection. Each of the piping that connects to the  
25 end fitting is on the side. It's not through the end.

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1 The end is reserved for the fueling machine connection  
2 so that we have a channel closure that normally seals  
3 the reactor coolant boundary, and the fueling machine  
4 would be sequenced to take out the channel closure  
5 before and also take out the seal plug, which is the  
6 shooting (phonetic) at the end of the channel, and  
7 then the refueling action can take place after these  
8 two internals are removed.

9 So you will hear more details regarding  
10 the on-line refueling operation, but that is the basic  
11 sequence and the interfaces.

12 So the feeder connections are all  
13 identical at the entity itself, but the feeder routing  
14 at the reactor phase would be according to the  
15 relative where they were on the reactor phase itself.

16 DR. ROSEN: Before you get off this, I  
17 think that first bullet deserves some comment. This  
18 is a leak before break philosophy for the pressure  
19 tubes, usually before break, before piping, under  
20 certain cases as well, but we also include in the  
21 design basis space the instantaneous failure of the  
22 largest pipe in the system.

23 So do you take into account in safety case  
24 analysis a more stringent case than this?

25 MR. YU: Yes.

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1 DR. ROSEN: The instantaneous failure of  
2 a pressure tube?

3 MR. YU: Yes. In the safety case, we do  
4 analyze the instantaneous rupture of the pressure tube  
5 and its effect on the injection into the calandria and  
6 also we even have to do a what if situation if it does  
7 break the calandria tube as well, although the design  
8 is such so that the moment is designed to contain the  
9 pressure tube rupture, but in the safety case we do  
10 analyze the other.

11 DR. ROSEN: The instantaneous case is  
12 analyzed in the safety case.

13 MR. YU: That's right.

14 DR. SHACK: Is this figure roughly to  
15 scale? Is the end fitting that long?

16 MR. YU: It is roughly. It is to scale.

17 DR. SHACK: To scale. Okay. Yeah, your  
18 drawing in your booklet isn't to scale, and I'm having  
19 a hard time reconciling the two.

20 MR. YU: I think what you see in the other  
21 case picture is from this tube sheet onwards because  
22 I think that, you know, you've got the two tube  
23 sheets. The only outer tube sheets can be seen.

24 DR. SHACK: Okay.

25 MR. YU: In normal operation, you know,

1 all of these would be inside a feeder cabinet as well  
2 so that when you look at the old review, you would not  
3 be able to see all of the details. So, yeah, P is a  
4 little bit shorter, especially the first picture you  
5 saw. It has, you know, the cover of the insulation.

6 So I think one thing I want to highlight  
7 is all our reactivity mechanisms, including the  
8 shutoff rods and also the poison injection, the past  
9 poison injection system, are all going into, they are  
10 located within the moderator space. So they are not  
11 in the high pressure system at all. So they go in  
12 between the lattice, outside of the calandria tube.

13 CHAIRMAN KRESS: I found it interesting  
14 that your control rods are separate from your shutdown  
15 scram rods, and you have, in addition to the scram  
16 rods, you have a separate boron injection system that  
17 will shut down the reactor.

18 MR. YU: We have a gadolinium injection  
19 system.

20 CHAIRMAN KRESS: Gadolinium, gadolinium,  
21 okay. So it's pretty good defense in depth, in my  
22 mind, from the standpoint of one of the key safety  
23 issues, and that is shutting off the reactor.

24 MR. YU: Yeah, we do have two safety grade  
25 fast shutdown systems, and in addition we do have, for

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1 normal power control, we have the additional rods so  
2 that we can have fast step-back, even to avoid the  
3 shutdown system to come in.

4 So that practically we do have the three  
5 means of shutting down.

6 DR. ROSEN: Why did you choose gadolinium  
7 for the injection system rather than boron?

8 MR. YU: Victor, can you?

9 MR. SNELL: I'm not 100 percent sure. My  
10 understanding is it's a lot easier to get out of the  
11 system once you put it in and that you'll gradually  
12 burn out as well, but I mean, that choice has gone  
13 back to the very early days of CANDU, and I think it  
14 was a matter once you get boron in the moderator, it's  
15 hard to get out again.

16 DR. WALLIS: So the thermal expansion of  
17 these tubes is quite a lot, isn't it? The pillars  
18 have to take up a lot of expansion.

19 MR. YU: yes.

20 DR. WALLIS: How much is that? It's quite  
21 a lot, isn't it?

22 MR. YU: Four inches?

23 DR. WALLIS: Four inches. It's quite --  
24 well, that seems a lot to me.

25 MR. YU: Can you explain, please? Sorry.

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1 Mark.

2 MR. LEGER: Mark, yeah.

3 The thermal expansion isn't very much, but  
4 there is some channel elongation that I'll be talking  
5 about.

6 DR. WALLIS: The elongation is due to  
7 neutronic effects?

8 MR. YU: Due to flux, yes.

9 DR. WALLIS: Change in the material  
10 itself.

11 MR. YU: Due to irradiation, it does creep  
12 with time. So I think into bellows they're to take up  
13 time.

14 DR. ROSEN: And that's a percent of the  
15 total elongation would you say that the neutron  
16 lengthening is 90 percent of 95 percent of the amount  
17 of lengthening you have to accommodate versus the  
18 thermal growth?

19 MR. YU: Thermal, thermal is very small in  
20 comparison. So I think certainly it will be five, ten  
21 percent at right range.

22 MR. LEGER: It's a relatively small  
23 fraction. I can work it out. I don't have it in my  
24 head.

25 DR. WALLIS: So the tubes, when they're

1 subject to all of this radiation decide to grow  
2 lengthwise rather than sag?

3 MR. YU: One thing that might be too small  
4 in here to show, we do have spaces. There are four  
5 spaces in the gap. We supported along the length, and  
6 they're fixing in place so that you do have  
7 interspacer small sag. That happens, and  
8 diametrically it will also creep.

9 DR. WALLIS: Don't spacers slide along the  
10 calandria tube?

11 MR. YU: Yeah, the spacers would slide  
12 along the calandria tube. It's tight around the  
13 pressure tube.

14 CHAIRMAN KRESS: The calandria tubes on  
15 the outside are not spaced. They can sag.

16 MR. YU: But the calandria tube is -- it's  
17 operating at a much lower temperature as well. So it  
18 hasn't got the pressure in it so that in terms of the  
19 formation, it would be much smaller.

20 DR. ROSEN: Well, does it grow lengthwise  
21 as well?

22 MR. YU: Mark?

23 MR. LEGER: It's not part of my  
24 presentation, but the calandria tubes don't change  
25 dimension very much in the reactor.

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1 DR. ROSEN: Why is that? They're made of  
2 the same material.

3 MR. LEGER: No. The pressure tube is cold  
4 worked zirc-niobium, and the calandria tubes are  
5 annealed, stress relieved Zircaloy-4.

6 MR. YU: I think the operating  
7 temperature, as well as the pressure is subject to  
8 within the reactor coolant system, would thus create,  
9 you know, high stresses in making the creep bigger.

10 So in terms of core design, the on power  
11 refueling is also part for the long-term reactivity  
12 control because, you know, the channel fuel  
13 replacement would dictate how the core reactivity  
14 change would be. Typically a total of 9 milli-K in  
15 the control devices, and we have additional what we  
16 call control absorbers. They are used for fast power  
17 changes. If we need to step back to avoid the  
18 shutdown system from coming in, we don't need boron,  
19 as mentioned before in the reactor coolant itself.

20 The control rod ejection is not one of the  
21 analysis case that we need to look at because of the  
22 low pressure environment that it offered in, and it  
23 does not interact with the few.

24 DR. ROSEN: Now, if you have a pressure  
25 tube failure, clearly the calandria will go to a

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1 higher pressure.

2 MR. YU: Yes.

3 DR. ROSEN: But what is that higher  
4 pressure? Typically it operates at 30 psi, I think  
5 you said.

6 MR. YU: Yeah, roughly it is at the top of  
7 the calandria so that it would be below at the design  
8 pressure itself.

9 DR. ROSEN: Which is?

10 MR. YU: Which is around the 30 psi. It's  
11 operating around ten.

12 DR. ROSEN: Oh, operating is ten?

13 MR. YU: Ten, 15, in that region.

14 DR. ROSEN: So if you lose a pressure  
15 tube, it will go to 30, and then the rupture disks  
16 will relieve.

17 MR. YU: Yeah. Temporarily it might be  
18 subjected to, you know, the pulse pressure, but then  
19 as soon as it's relieved --

20 CHAIRMAN KRESS: Where is it relieved  
21 into?

22 MR. YU: It is relieving into the vault  
23 (phonetic) itself, the reactor, the reactor building.

24 So this gives you --

25 DR. ROSEN: I mean, is that expected if

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1 you have a pressure tube failure on the calandria?

2 MR. YU: No. I think, you know, that the  
3 expectation would be that it would pressurize the  
4 endless space between the calandria tube and the  
5 pressure tube, and then you would see possibly slow  
6 leaks through those small tubings were the gas  
7 normally circulates.

8 DR. ROSEN: Okay. So you don't expect the  
9 pressure -- calandria tube failure on a pressure tube  
10 failure?

11 MR. YU: Not normally, even though in  
12 analysis you assume that it might cause failure.

13 MR. SIEBER: Well, that's where the  
14 ballast is. Would it not --

15 MR. YU: The ballast would deform.

16 MR. SIEBER: Yeah, it would rupture that  
17 before it would rupture the tube, calandria tube?

18 MR. YU: It's possible, but I think, you  
19 know, that in terms of deformation pressure, you can  
20 take a lot more.

21 MR. SIEBER: Okay.

22 DR. WALLIS: So all of these tubes are  
23 unsupported over their length and the control system  
24 slides in between them?

25 MR. YU: The calandria tubes are not

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1 supported along the length, no. It is relying on the  
2 two end tubes.

3 DR. WALLIS: So they must remain straight  
4 then. If they buckled in any way, they would  
5 interfere with your reactivity control devices.

6 MR. YU: That's correct. I think from  
7 operational reactivity viewpoint, some may say it  
8 would tie (phonetic), but that is small.

9 In terms of the reactivity mechanisms,  
10 they are all in the interspace between the lattice.  
11 So that's why, you know, in a gravity operation it  
12 would not interfere with the control mechanisms.

13 So certainly as part of the safety  
14 evaluation, you do assume the shutdown devices  
15 adjacent to the first pressure tube to be disabled.  
16 So it is apart of the analysis assumption that you  
17 assume that they are not affected.

18 DR. WALLIS: You're assuming that there is  
19 nothing to move them horizontally, but presumably if  
20 there is a flux distribution, they could have  
21 different irradiation on one side than the other, and  
22 if there are neutron effects changing the materials,  
23 this could lead to a change in the geometry of the  
24 tube.

25 MR. YU: I believe this is unlikely,

1 but --

2 DR. WALLIS: Well, presumably you have  
3 experience. I mean, you measured these things.

4 MR. YU: But operating experience is such  
5 that --

6 DR. WALLIS: So you don't really take the  
7 tubes every two years or something.

8 MR. YU: -- we have not observed those.  
9 We have not observed anything like that.

10 DR. WALLIS: Well, you may not have  
11 observed anything. You maybe observed something. It  
12 would be nice if you had observed something and you  
13 could bracket it.

14 MR. YU: Okay. In terms of numbers, we  
15 have a nine zone control, which is really for regional  
16 power adjustment, and we have full control of stubbers  
17 (phonetic). Those are the ones that that are used for  
18 fast power step-back or setback.

19 Shutdown system number one, we have 20  
20 shutoff units, and there are six injection nozzles.  
21 In the safety system description I'll give you more  
22 details of that.

23 As already mentioned, the total  
24 (unintelligible) void is minus 7 million K.

25 DR. WALLIS: This prompt neutron lifetime,

1 is the lifetime of a neutron from fission to  
2 absorption its whole lifetime, not just while it's  
3 prompt. I mean it's --

4 MR. YU: Peter, can you clarify?

5 DR. WALLIS: It must be its whole  
6 lifetime.

7 MR. CHAN: This is Peter Chan from the ACL  
8 Physics,

9 I believe our definition is the neutron,  
10 the lifetime from fission, from the fission born to  
11 being absorbed.

12 DR. WALLIS: Which is the whole lifetime.

13 MR. CHAN: The whole lifetime.

14 DR. WALLIS: So it's the neutron lifetime.

15 MR. CHAN: That's right, but for the plump  
16 part (phonetic).

17 DR. WALLIS: Yeah, yeah. There are so few  
18 of the delayed.

19 MR. CHAN: That's right, yeah.

20 This is the neutron life and from the plump part  
21 of the neutron.

22 DR. WALLIS: Presumably also very closed  
23 the life of the delayed fraction as well once they've  
24 been emitted

25 MR. CHAN: Yeah, I believe so, yeah.

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1 DR. ROSEN: And this total coolant void  
2 reactivity is if you lose all of the coolant in a  
3 channel; is that correct?

4 MR. SNELL: In the core itself, the entire  
5 core.

6 DR. ROSEN: The whole core.

7 MR. SNELL: The whole core. It's a full  
8 core void reactivity.

9 DR. ROSEN: All of the pressure tubes go  
10 dry.

11 MR. SNELL: That's correct.

12 MR. YU: Okay. I already mentioned about  
13 the two percent outlet quality in the reactor coolant  
14 system towards the other end, and the --

15 DR. WALLIS: Is this the equilibrium  
16 quality? So, in fact, because of subcooling, there  
17 would be a higher quality in terms of a fraction of  
18 steam.

19 MR. YU: No, this is the maximum quality  
20 that we're expected to operate.

21 DR. WALLIS: Is this the equilibrium  
22 thermodynamic quality or is it a physical quality  
23 taking account of subcoolant?

24 MR. YU: This is the fraction of steam  
25 weight quality in the reactor coolant system under

1 steady state operation. I was going to say when the  
2 steam generator knew that it would have far more heat  
3 transfer, so initially all of our reactors operate in  
4 subcool conditions.

5 But this is design conditions, assume the  
6 design fouling (phonetic) for the steam generators  
7 before you arrive at that, based on operating  
8 experience that would arrive at, you know, at some  
9 time later, before you need to clean the steam  
10 generators and so on.

11 So I think this is the reference maximum.

12 DR. WALLIS: So the water leaving the  
13 tubes is saturated.

14 MR. YU: The water at the outlet header at  
15 saturation where the pressurizer is located, yes.

16 DR. WALLIS: I'm saying this because you  
17 know you realize that they could be subcooled and then  
18 it could condense on its way to the header. So I'm  
19 not --

20 MR. YU: No. I think in the reference  
21 design conditions, given two percent quality going  
22 into the inlet plenum of the steam generators, so we  
23 do have a condensation zone within the steam generator  
24 itself. So --

25 DR. WALLIS: This is an equilibrium.

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1 MR. YU: -- heat transfer --

2 DR. WALLIS: It's essentially an  
3 equilibrium quality then.

4 MR. YU: Yes, yes, yes.

5 The last bullet references the fact that  
6 when you have a postulate to pressure tube and  
7 calandria tube rupture, the light water coolant would  
8 gain to the moderator that the mixing has the effect  
9 of reducing the reactivity. So it does smooth it in  
10 the right direction.

11 DR. WALLIS: Are the flow fluctuations  
12 with all of these parallel channels in operation?

13 MR. YU: Not according to our design. I  
14 think, you know, that actually in this diagram if you  
15 look at the interconnect between the two reactor  
16 header, its design function is to make sure that there  
17 is no channel-to-channel instability. So that's  
18 designed such so that you will avoid that.

19 Because it is a figure of eight loop, the  
20 reactor coolant goes through the core twice. Half of  
21 the channel has the inlet connected to one end. It  
22 comes out, and then it goes through a steam generator  
23 and heat transfer pump. And then it goes through the  
24 other half of the channel in the other direction.

25 CHAIRMAN KRESS: Now, these are staggered

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1 by the lines. One line would have one direction and  
2 the next line --

3 MR. YU: No. We have alternate channels  
4 both above and below. So if you look at the diagram,  
5 we have one going in the -- one next to it, both  
6 above, on the side, all four channels surrounding it  
7 in the opposite direction.

8 CHAIRMAN KRESS: Yeah, that's what I was  
9 saying.

10 MR. YU: Yes, that's right. On each roll  
11 that's what it is, and the adjacent roll is staggered.

12 CHAIRMAN KRESS: It's on each roll, right.

13 MR. YU: So the range of sizes that we  
14 have ranges from two inches on the reactor phase  
15 because of the space, and it goes to the three and a  
16 half inches for the outlet so as to balance the  
17 pressure drop. So we design each of the channels for  
18 equal pressure drop, sizes and lengths.

19 CHAIRMAN KRESS: How do you control the  
20 flow? Is it just because your headers are a big  
21 volume compared to the feeder lines?

22 MR. YU: That's correct. It's really a  
23 header --

24 CHAIRMAN KRESS: There's no individual  
25 orifice.

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1 MR. YU: I think in the operating reactors  
2 you do. In this design I'm not too sure whether we  
3 need -- I don't think we need any orifices on this  
4 design. We have simplified it, especially the called  
5 profile is relatively flat for the ACR. We don't need  
6 to use orifices, but in CANDU 6 we have, to use for  
7 the outer channel especially. The TOX-4 file  
8 (phonetic) is more of the (unintelligible) across the  
9 reactor face.

10 So the parallel series palm (phonetic)  
11 arrangement, you always have two of these pumps  
12 operating in series. So on the prostrate pump issue,  
13 you still have the other pumps on the opposite end to  
14 push the coolant through the core.

15 These things are above the core so that  
16 when we analyze header breaks, that the remaining  
17 channels would still be refueled. Certainly after  
18 LOCA there's no preferred direction for the channel  
19 flow in the long term because the long-term cooling,  
20 which is the equivalent of the residual heat removal  
21 system, would be circulating the water through the  
22 header into each of the channels depending on where  
23 the postulated break is.

24 DR. RANSOM: The fuel tubes that are  
25 inside the matrix, are they spaced far enough apart,

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1 I guess, that the feeder pipes can flow, pass between  
2 the adjacent tubes?

3 MR. YU: Yes.

4 DR. RANSOM: In order for this coolant to  
5 get to the internal central, say, assemblies?

6 MR. YU: The space between the  
7 (unintelligible) is sufficient for oil (phonetic)  
8 feeders to conduct. So that has been our design for  
9 all of the CANDU reactors in the past. The layout is  
10 such that we would be able to, you know, given to  
11 unhook the feeders if we can to a single free channel  
12 replacement.

13 DR. RANSOM: Are you going to talk later  
14 about the seals that are -- you know, you have sealing  
15 between gas spaces, light water, then heavy water and,  
16 you know, passing through the shield tanks, as well as  
17 the calandrium. It seems like there are an awful lot  
18 of seals. I wonder if they're welded or if there are  
19 some bellows I know.

20 MR. YU: I think we will be talking about  
21 the row joints between the pressure tube and the  
22 entity, but that's really the only connection for the  
23 reactor cooling within the core itself. The other CUs  
24 are really to her self-contained boundaries because  
25 they are located in between, like the (unintelligible)

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1 is reoccupying the space in between. So from the  
2 bellow itself, it would have connection to the system  
3 for leak detection.

4 So I don't have a detailed diagram in  
5 here, but we can illustrate that further. Certainly  
6 you see some further cross-section of the boundary  
7 later on.

8 CHAIRMAN KRESS: Your feeder tube is Zirc-  
9 4?

10 MR. YU: No. Feeder tubes are stainless  
11 steel.

12 CHAIRMAN KRESS: And the headers are?

13 MR. YU: The headers are carbon steel.

14 CHAIRMAN KRESS: So this similar weld is  
15 where the feeder tube goes into the pressure tube?

16 MR. YU: Yeah. We have these similar  
17 welds at the top end here, close to the header.

18 DR. SHACK: Oh, so the whole feeder tube  
19 is stainless steel. I thought there was a transition  
20 to a carbon steel.

21 MR. YU: Yeah. I think we have been  
22 optimizing to see where would be for inspectability.  
23 So --

24 DR. SHACK: How about magnet type  
25 deposition of your steam generator tubes.

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1 MR. YU: We did have that.

2 DR. SHACK: Yes.

3 MR. YU: In the current operating CANDUs.  
4 So I think in terms of erosion/corrosion, the original  
5 reference design to put all of the ICSIT (phonetic) as  
6 well as the bottom half of the feeders, all stainless  
7 steel, and then we have the challenge regarding the  
8 similar metal weld particularly from the inspection  
9 viewpoint as to how can we, you know, do good  
10 inspection, and we have been contemplating what is the  
11 best location for that.

12 So I think what we are hearing is really  
13 what our latest thinking is. It does not change the  
14 design itself, except that where the transition weld  
15 would be.

16 So it is now much closer to the header  
17 itself. It's still being finalized in terms of stress  
18 analysis, and then inspectability.

19 DR. FORD: So there's no decision about  
20 the details of these dissimilar metal welds between  
21 the carbon steel and the stainless steel structure?

22 MR. YU: The details have been worked out,  
23 except --

24 DR. FORD: So it will not be, I assume, a  
25 straight stainless steel to carbon steel weld. There



1 will be some buttering. There will be some incanel  
2 alloys.

3 MR. YU: Well, I think it's a straight  
4 weld, but, Mark, can you clarify? I think it's a  
5 straight weld, but, Mark, can you clarify?

6 MR. LEGER: I don't have all of the  
7 details, but there would be involved -- it would have  
8 an intermediate metal, yeah.

9 MR. YU: So you will hear more about the  
10 on-power refueling, but this is the arrangement, how  
11 it is supported. The fueling machine head would be  
12 where the fuel bundle are being retrieved and stored  
13 and then take it out.

14 The way it is taken out is the fueling  
15 machine head would accept new fuel from the port at  
16 the containment boundary, and then going to the  
17 machine, and then once you have put into the reactor  
18 on the other side, it comes out and you put into the  
19 spent fuel receiving bay, and then the storage bay is  
20 where they would be stored.

21 CHAIRMAN KRESS: Is that storage bay  
22 inside your containment area?

23 MR. YU: No. The storage area is outside  
24 containment. That's our containment.

25 CHAIRMAN KRESS: Oh, that's your

1 containment.

2 MR. YU: That's our containment boundary.

3 DR. ROSEN: Now, these CANFLEX assemblies  
4 are in a horizontal position in the core, and they're  
5 moved out in a horizontal position.

6 MR. YU: That's right.

7 DR. ROSEN: Until they get to the spent  
8 fuel storage area, but then they have to be tilted,  
9 right?

10 MR. YU: That's right.

11 DR. ROSEN: Brought into the vertical  
12 position and slid down into the racks. Are you going  
13 to describe how you do that?

14 MR. YU: Well, I think you can explain  
15 that later in the on-line refueling. I think what we  
16 have done here is a little bit different from what it  
17 was before. In current operating reactors, they are  
18 stored in the racks, and they still remain in the  
19 horizontal position, but then when the transition to  
20 dry spent fuel storage, they are put into baskets and  
21 then put into the dry spent fuel storage.

22 So what we have done is to minimize the  
23 handling by designing the baskets within the bay so  
24 that they would be able to, you know, put into similar  
25 position and then so that it simplifies safeguards and

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1 so on.

2 DR. ROSEN: But you have to make the tilt,  
3 the up ending --

4 MR. YU: Yes, that is correct.

5 DR. ROSEN: -- in this operation, and  
6 that's what I'm interested in.

7 MR. YU: That is the fuel transfer system  
8 to be able to do that.

9 CHAIRMAN KRESS: While you've got that  
10 picture and it's on my mind, could you tell me a  
11 little about the containment, how bit it is in volume  
12 and pressure, design pressure?

13 MR. YU: The containment, it is 39.5  
14 meters in diameter and 59 meters height to the bottom  
15 of the dome, and the containment thickness here is  
16 about 1.2 meters, and the dome thickness is around one  
17 meter, and the containment free volume is about 58,000  
18 cubic meters. The design pressure --

19 CHAIRMAN KRESS: And it's a free standing  
20 steel structure?

21 MR. YU: It is a steel lined pre-stress  
22 containment. The design pressure is 450, which is  
23 really being dictated by the steam line break.

24 DR. SHACK: The impression I get is that  
25 this is different than the CANDU containment.

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1 MR. YU: Yes.

2 DR. SHACK: What's the difference?

3 MR. YU: The CANDU 6 containment do not  
4 have a steel line. It has a plastic liner, and also  
5 the criteria for the peak pressure are different in  
6 our reference (unintelligible) environment. So it  
7 does be able to withstand the main peak pressure. So  
8 the design pressure is generally slower in the CANDU-  
9 6.

10 And also, CANDU-6, I must add that we do  
11 have a dousing tank which is to reduce the peak  
12 pressure at the top of the dome. For the ACR design  
13 we have adopted a dry containment.

14 CHAIRMAN KRESS: I hate to inhibit  
15 questioning, but we're getting already behind time.  
16 Can we go --

17 MR. YU: I think I need to go faster.

18 CHAIRMAN KRESS: I know it's our fault,  
19 but could you please.

20 MR. YU: Okay.

21 CHAIRMAN KRESS: And we'll try to restrain  
22 ourselves a little bit.

23 MR. YU: So shut-down systems, I think  
24 that, you know, it shows the reactivity mechanisms  
25 back here, and I'll give you a cross-section of the

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1 shutdown system number one. The absorber material is  
2 in the kind of flat, rectangular cross-section.  
3 Normally, you know, that is packed outside the core,  
4 and it is dropped by gravity into the core itself, and  
5 the mechanism to drive is really to raise it up to the  
6 reactor scram.

7 CHAIRMAN KRESS: There's 20 of those?

8 MR. YU: We have 20 of these, yes.

9 CHAIRMAN KRESS: And you only need ten of  
10 them to shut down the --

11 MR. YU: Sorry?

12 CHAIRMAN KRESS: You only need ten of them  
13 to actually shut down the reactor or do you need all  
14 20 of them?

15 MR. YU: I think we do have margins, but  
16 not ten. We need to postulate some under testing or  
17 some other failed to operate single failure criterion.

18 CHAIRMAN KRESS: Yeah.

19 DR. ROSEN: Clearly these are packed  
20 outside the core, but are they parked outside the  
21 calandria as well?

22 MR. YU: They are, yes. This is the  
23 calandria shell. So they are normally --

24 DR. ROSEN: Normally above, the tip is  
25 above the outside of the calandria shell.

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1 MR. YU: Yes, yes.

2 DR. ROSEN: So they see no neutrons in  
3 their normal operation.

4 MR. YU: No. For the shutdown system  
5 number two, we have six of these gadolinium injection  
6 tanks. They are injected by nozzles. They are  
7 located on the reflector region of the core so that  
8 we've got three on top and three on the bottom. Their  
9 performance is similar within less than a second. The  
10 poison would be injected into the core prior to  
11 shutdown.

12 CHAIRMAN KRESS: They are protected by gas  
13 pressure?

14 MR. YU: By helium gas pressure normally  
15 operating around 8 MPa.

16 So for emergency core cooling system we  
17 have the accumulated tanks and each one would be  
18 connected to the reacting headers. As part of the  
19 outlet headers, we have the emergency core cooling  
20 operation. They would be connected under that  
21 injection mode so that depending on where the break  
22 is, you always have flow through the core.

23 And for the intermediate mode, we have the  
24 reserve water tank, which is 2,500 cubic meter of  
25 water capacity. The majority of that water is used

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1 for flooding the sump, and that would be the initial  
2 cool water injection after the accumulated tanks are  
3 emptied.

4 CHAIRMAN KRESS: How does it get down to  
5 the sump?

6 MR. YU: Sorry?

7 CHAIRMAN KRESS: How does it get to the  
8 sump? Are there spray nozzles?

9 MR. YU: No. It's just a straight  
10 galkamer (phonetic) pipe. The valves open up, and  
11 then it just floods the sump.

12 The normal isolation between the  
13 accumulators, we use the one-way rupture disk so as to  
14 simplify the valve operation because this rupture disk  
15 would stand the full reactor coolant pressure during  
16 normal operation, and then on the much lower  
17 (unintelligible) pressure on the other end, then it  
18 would burst the disk.

19 These devices have been completely tested  
20 in our laboratories.

21 There's also the floating ball shutoff  
22 (phonetic) that would, you know, when the water gets  
23 down to low level, then you see the bottom of the tank  
24 that would prevent the gas from getting in.

25 CHAIRMAN KRESS: Will we see more about

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1 the design details of that one-way rupture? How do  
2 you achieve a high pressure resistance in one  
3 direction and not in the other?

4 MR. YU: No, the idea is not to -- oh,  
5 it's a rupture disk that has a backing plate, and it's  
6 a full hose on that backing plate. So on the reverse  
7 direction it has all of the support by the backing  
8 plate and only in the forward direction. Then the  
9 full pressure is applied to the full diameter. So  
10 it's such a differential area that gives you the  
11 differential bursting.

12 So for the long-term cooling, this would  
13 be the part that would be used to flood the sump and  
14 then we have redundant pumps for each of the reactor  
15 and the header through the evolving arrangement.

16 DR. ROSEN: I'm sure you're following the  
17 discussions here in this country on pressurized water  
18 sump plugging effects.

19 MR. YU: Yes.

20 DR. ROSEN: And it seems that this design  
21 is susceptible to the same difficulties. Can you  
22 comment on that?

23 MR. YU: We essentially have followed the  
24 very earlier, every since the initial incident  
25 regarding insulation, plugging, faulty material, and

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1 sizing of the sump, whether, you know, it meets single  
2 failure or not.

3 So we have selected insulation materials  
4 appropriately. The latest that we have noticed, I  
5 think we are looking into that. Some of the chemistry  
6 effects which we are monitoring. So our designers are  
7 looking to the latest bulletin on this subject.

8 This is just a parameter that the ten wall  
9 units of 170 cubic meters in each of the two tanks;  
10 the pressure for injection is about 5 mph.

11 The containment I already mentioned about  
12 the sizes and the design pressure. We are using the  
13 air coolers that are located at the strategic places  
14 for heat removal. I do have a diagram to show that.

15 We use passive autocatalytic combiners for  
16 the core damage accident.

17 CHAIRMAN KRESS: And those are sufficient  
18 to deal with all of the hydrogen you might get  
19 generated in a severe accident?

20 MR. YU: The scenario that we posted,  
21 maybe, Victor, can you elaborate a little more if you  
22 need to?

23 MR. SNELL: This is an interesting area  
24 where we're actually trying to meld two regulatory  
25 philosophies. There is no need for hydrogen control

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1 mechanisms for design basis accidents. So these are  
2 put in for what's required. In Canada we're required  
3 to look at what's called dual failures. I guess we  
4 call it dual failures, but they're basically an  
5 accident plus an impairment or a failure of a safety  
6 system.

7 So in this particular case, you would be  
8 looking at loss of coolant with failure of the ECC to  
9 inject, and when you do that, you produce hydrogen  
10 through oxidation of the sheets. Although one would  
11 say that's a severe accident, we nevertheless provide  
12 design mitigation of it. That's why the hydrogen  
13 control is there.

14 CHAIRMAN KRESS: We'll probably hear more  
15 about that some time later.

16 Are these the European, German designs or  
17 are these your own design?

18 MR. SNELL: These are our own, passive  
19 autocatalytic combiners.

20 MR. YU: I believe we have supplied some  
21 of these to Finland as well for their use.

22 I talk about the local air vault coolers.  
23 This is really a schematic as you show where the  
24 normal circulation would be.

25 Severe accidents. The reserve water tank

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1 that I mentioned earlier not only supplied the water,  
2 but part of the water is for the make-up to the steam  
3 generators on lots of normal CBR heat sync makeup, and  
4 also it can provide makeup to the moderator, as well  
5 as the shield tank.

6 So this allows us, you know, to make up  
7 the water surrounding the reactor coolant system  
8 because the heavy water moderator is just on the  
9 outside of the calandria tube.

10 DR. APOSTOLAKIS: Why do you need to  
11 provide makeup water to the moderators?

12 MR. YU: This is part of our severe  
13 accident mitigation backup so that if you are on a  
14 severe accident scenario, if by any chance that your  
15 core is severely damaged, then it would be boiling off  
16 the moderator. So that in order to replace the water  
17 to allow it for a longer heat sync, then --

18 DR. APOSTOLAKIS: So it's really cooling.

19 MR. YU: Cooling, yes, for heat removal  
20 under severe core damage event. So you can see that  
21 the moderator is surrounding it, and then so when we  
22 provide the makeup, then our situation when the  
23 calandria tube is still intact, you'll still be able  
24 to remove the heat and on progressively more damage  
25 situation, then you still have the seal water

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1 (phonetic) surrounding it. That would be able to do  
2 the heat removal, can see the (unintelligible) water  
3 is about four times that of the calandria moderator  
4 water at least.

5 So the moderator system normally would  
6 remove the fission heat appearing in the moderator  
7 itself. So when it continues to operate, it will  
8 remove about five percent of the heat. So, therefore,  
9 it can be an emergency thing under severe core damage  
10 type of events.

11 I already mentioned that. In view of  
12 time, and because, as I mentioned, we have the control  
13 system as well as two independent shutdown systems,  
14 and we normally, when we look at the frequency of  
15 anticipated transients without scram, the frequency is  
16 so low that we don't normally analyze it.

17 But even in a sequence where the core  
18 damage is loss within the calandria, it would still be  
19 contained because, you know, that water is on the  
20 outside. And I did mention the makeup under the  
21 (unintelligible) water system.

22 Operation of features. As I mentioned, we  
23 do need to look at some of the features to provide  
24 more on-line terror. That's what our customers are  
25 demanding, certainly from the management team

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1 interface and reliability viewpoint that we need  
2 enhancement.

3 In terms of the operational error, we are  
4 paying more attention to the control design and also  
5 in terms of the control room, we have an improved  
6 alarm recognition system, as well as the last screen  
7 display.

8 DR. APOSTOLAKIS: But I thought you were  
9 going to say that you're giving more time to the  
10 operators to act. What is the shortest time they have  
11 to act? I mean, you just said earlier that severe  
12 core damage can be delayed for hours.

13 MR. YU: Oh, I think, you know, in terms  
14 of severe core damage events, it's way beyond 24  
15 hours, if not longer. Victor?

16 MR. SNELL: Victor Snell.

17 I'll try and give a summary. On single  
18 events, what we were trying to do in this design is to  
19 give the operator about eight hours before he has to  
20 do something. Obviously a severe core damage event is  
21 a combination of many events, and there are exceptions  
22 to the eight hours, particularly things like if you  
23 have a steam generated tube rupture and you're then  
24 required to isolate the effect of the steam generator.  
25 That would need to be done before eight hours.

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1                   There's a couple of exceptions, but by and  
2 large, the automatic systems will take the operator  
3 through a single event, a single initiating event for  
4 about the first eight hours.

5                   MR. YU: In terms of the control room, we  
6 have installed a prioritized alarm system with color  
7 coding so that it makes the operator be able to  
8 recognize the event faster in terms of screening out  
9 some of the duplicate alarms that come in on  
10 duplicated channels.

11                   In terms of help monitor, we have more  
12 systems that would be able to look at the chemistry  
13 trends, for example, which is what we have the  
14 chemistry command system so that on any chemistry  
15 excursion we will be able to do support analysis, the  
16 variation as well regarding what's to be done and what  
17 chemicals need to be added for --

18                   DR. FORD: Now, the last bullet is  
19 predictions. Predicting what, materials degradation?

20                   MR. YU: In terms of material degradation  
21 and, for example, in terms of cleaning, what would be  
22 the plan versus, you know, the predicted time, whether  
23 you can restore the performance.

24                   DR. FORD: So you have got the algorithm  
25 for amount of degradation of the pressure tube, for

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1 instance, as a function of time and as a function of  
2 various other parameters, operating parameters?

3 MR. YU: Not on the pressure tube itself.  
4 Mainly talking about in this particular case it's  
5 steam generators monitoring, for example, and even  
6 primary chemistry monitoring because I think we need  
7 to control it for the reactor coolant on a certain pH,  
8 as well as chemistry limits, and that will give you  
9 the monitoring of what's going on.

10 DR. FORD: So forget about pressure tube  
11 for the steam generator tubes, for instance. You've  
12 got algorithms of expected time to first failure as a  
13 function of secondary and primary water chemistries.

14 MR. YU: They are not really for safety  
15 monitor. This is really more for operational in terms  
16 of chemistry control, chemical additions, cleaning of  
17 the steam generator --

18 DR. FORD: Okay. So it's more operational  
19 predictions.

20 MR. YU: It's operational oriented, yes,  
21 not safety.

22 MR. LEITCH: If one is operating less than  
23 the four main reactor coolant pumps, must you be  
24 operating a particular combination of those pumps?

25 MR. YU: We do not design this to operate

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1 with partial pumps.

2 MR. LEITCH: So you must be operating all  
3 four pumps?

4 MR. YU: Yes.

5 MR. LEITCH: Not the right two. I mean  
6 you cannot operate with just the right two pumps?

7 MR. YU: At start-up we can operate with  
8 one pair initially until it gets up into higher  
9 temperature, and then you start the -- they start it  
10 in a staggered manner, but for pull power operation,  
11 that's not designed for partial pump operation.

12 DR. ROSEN: So you trip the reactor if you  
13 lose the coolant pump?

14 MR. YU: Yes.

15 MR. LEITCH: How is the --

16 CHAIRMAN KRESS: I honestly -- go ahead.

17 MR. LEITCH: How is the SCRAM System II  
18 initiated or the shutdown System II? How is that  
19 initiated, manually or --

20 MR. YU: No. IT's all relying also on the  
21 range of trip signals as well, like, you know, the low  
22 header pressure, high header pressures, and so on,  
23 neutronic trips as well as process trips for both of  
24 the shutdowns.

25 MR. LEITCH: But does the second system

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1 operate only if the first one has failed?

2 MR. YU: No. They are independent  
3 parameters. The set points are such so that it can be  
4 avoided to come in that they would be. So that the  
5 first shutdown system has much tighter set point. So  
6 that they would prefer to come in earlier.

7 Like, for example, in high reactor system  
8 pressure, how reactor coolant system pressure. Then  
9 the STS-1 set point is lower and the STS-2 is higher.

10 MR. LEITCH: And I had one other question  
11 about the term ACR-700. Some of your figures here  
12 just say ACR. Does the 700 apply to a particular size  
13 of ACR or is that all we're discussing at the moment,  
14 the 700?

15 MR. YU: It's just too long to repeat  
16 that. Oh, I think it is talking about ACR-700 in our  
17 design.

18 MR. LEITCH: Okay. So every place I see  
19 "ACR," I should assume that's a 700.

20 MR. YU: Assume ACR-700, yes.

21 MR. LEITCH: Okay, okay. Thank you.

22 MR. YU: So that's a picture of the  
23 Qinshan Ming (phonetic) control room that we would  
24 certainly replicate the last display as well as the  
25 advanced alarm system. The operation interface on the

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1 panel are going to be modified further based on human  
2 factors improvements.

3 DR. ROSEN: Is this a digital control  
4 room, fully digital or is it a hybrid, analog and  
5 digital?

6 MR. YU: Yes, we are using PCS for our  
7 control, as well as the shutdown systems. They're all  
8 computerized as well.

9 DR. ROSEN: My question is: is this a  
10 fully digital control room or do you use a lot of  
11 analog instrumentation as well?

12 MR. YU: I think I can say that we are  
13 fully digital in a sense because it's difficult. All  
14 the systems, we do have computerized shutdown system,  
15 as well as computer control for reactor control. So  
16 whether they are in your sense fully digital, I'm not  
17 too sure whether. I don't want to answer a yes  
18 because I don't know what you're referring to, but yet  
19 all shutdown systems are digital, computers control,  
20 as well as the reactor control. So we have computer  
21 control, and we're going to a PCS as well.

22 MR. SIEBER: I think one feature that I  
23 think I read about was the fact that you separate your  
24 protection system from your control systems.

25 MR. YU: Right.

1 MR. SIEBER: And in a digital sense not  
2 everybody does that, but I think that makes a better  
3 design.

4 MR. YU: Yes, we do separate shutdown  
5 systems from the reactor control.

6 So in summary, we place on a lot of our  
7 operating experience as well as our R&D regarding our  
8 product. We talk a lot about optimization regarding  
9 the different aspects of the design, including the  
10 operation feature.

11 We introduce a number of passive features  
12 in our design for safety. Operational aspect, we pay  
13 a bit more attention to the operating needs as well.

14 DR. ROSEN: Now, what is the nominal  
15 operating cycle? I know you don't have to refuel on  
16 line. So there's no arbitrary limit, but certainly  
17 you have in mind a time frame before you will shut the  
18 plant down and do a full maintenance.

19 Do you have some nominal time frame in  
20 mind?

21 MR. YU: Well, we are aiming for three  
22 years.

23 DR. ROSEN: Three years.

24 MR. YU: For plan outages because a lot of  
25 the mentions we can do on line as well.

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1 DR. ROSEN: But you can't maintain turbine  
2 on line.

3 MR. YU: No, not everything on line.

4 DR. ROSEN: So you have to on --

5 MR. YU: That's why every three years --  
6 some inspections used to be done also in certain  
7 cycles as well. So I think three years would be the  
8 way that we input. We have access to containment  
9 areas as well.

10 DR. WALLIS: Now, you're not presenting a  
11 PRA to us today; is that right?

12 MR. YU: Yes, that would be --

13 DR. WALLIS: You will? You will. Okay.

14 MR. YU: There will be a PRA presentation.

15 DR. ROSEN: But you haven't done the whole  
16 PRA.

17 MR. YU: -- methodology.

18 DR. ROSEN: The methodology will be  
19 discussed.

20 MR. YU: Yes.

21 DR. ROSEN: But you haven't completed it.

22 MR. YU: No.

23 DR. WALLIS: Well, that puzzles me a bit  
24 because it's stated that you use the PRA in design.  
25 If the design constraint is that the core damage

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1 frequency be ten to the minus five while you're doing  
2 your optimization, then it is ten to the minus five,  
3 and you don't have to do a PRA again because you've  
4 already done it as part of the design.

5 So I'm not quite sure why it hasn't been  
6 done if it's --

7 MR. YU: We've done Level 1 PRA, and also  
8 we have utilized our experience from the PRAs that  
9 were done for the CANDU 6 before. So the  
10 supplementary design assist PRA has been done.

11 In terms of an integrated Level 1 and  
12 Level 2 PRA, we're still in the process of doing that.  
13 So I think that in areas that we are changing from the  
14 CANDU 6, we have done the specific scenarios to see  
15 whether we are moving in the right direction or not.

16 DR. WALLIS: So the PRA should come out as  
17 you intended --

18 MR. YU: Yes.

19 DR. WALLIS: -- to be ten to the minus  
20 five CDF.

21 MR. YU: It's a case of documentation and  
22 the detail work in order to get that.

23 MR. SIEBER: It's probably a mistake to  
24 ever say that a PRA is truly done.

25 MR. YU: That's right.

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1 (Laughter.)

2 MR. SIEBER: You just keep on going and  
3 going.

4 DR. ROSEN: It's an oxymoron to say that  
5 this a completed PRA.

6 DR. APOSTOLAKIS: How do you conclude then  
7 that the ACR meets the NRC safety goals if the PRA is  
8 not complete? I mean that's what this document says  
9 that was sent to us earlier.

10 MR. YU: Well, we believe we have done  
11 enough to know that when the detailed documentations  
12 are done that we expect to be within the limits that  
13 we have set of the safety goal.

14 DR. APOSTOLAKIS: So if a PRA is submitted  
15 to us at some point?

16 MR. YU: Will be as part of the design  
17 certification.

18 DR. APOSTOLAKIS: By the way, the goals  
19 that you mentioned here are a little old, aren't they?  
20 We're not using ten to the minus five for core damage  
21 frequency, are we? It's four.

22 You remember OCRANT (phonetic) ranged an  
23 issue here some time ago that the goals were increased  
24 by a factor of ten without a formal process.

25 MR. SIEBER: That's right.

1 DR. APOSTOLAKIS: It's ten to the minus  
2 five for a larger list, but if you go way back, I  
3 think you will find ten to the minus six.

4 CHAIRMAN KRESS: Yeah, but there's this  
5 thing on the books that says the NRC has an  
6 expectation of a higher level of safety.

7 DR. APOSTOLAKIS: But it says goals.

8 CHAIRMAN KRESS: I know, I know, I know.

9 DR. APOSTOLAKIS: It's not expectations.  
10 Maybe that's something for us to worry about.

11 PARTICIPANT: That's why you've got to  
12 meet the goals.

13 CHAIRMAN KRESS: And I think the utilities  
14 require it.

15 DR. APOSTOLAKIS: It's not a problem.  
16 It's not a problem.

17 CHAIRMAN KRESS: Yeah, the utilities'  
18 requirements document calls for --

19 DR. APOSTOLAKIS: Now, I also tried to get  
20 some of the references that you list in this document  
21 by going to --

22 MR. YU: May I ask what document are  
23 you --

24 DR. APOSTOLAKIS: Well, it says "Safety  
25 Characteristics of the Advanced" --

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1 MR. YU: Oh, okay, yes. We can search for  
2 an item if --

3 DR. APOSTOLAKIS: Yeah, that's what I'm  
4 getting at. I was able to get a couple of them, but  
5 References 5, 6, and 7 I was unable to get. Can you  
6 make sure?

7 MR. YU: Yeah.

8 DR. APOSTOLAKIS: And eight, five, six,  
9 seven, and eight. Can you make sure we get copies?

10 CHAIRMAN KRESS: Could you send those to  
11 Ahmed and he'll see that those get distributed?

12 MR. YU: Okay.

13 DR. ROSEN: Now, while we're talking about  
14 additional needs for information, I read in Section  
15 2.8 in this same document, the safety characteristics  
16 of events, CANDU reactor designs by Waddington and  
17 Rogers that discussion of incorporation of past  
18 experience, and that a formal review had been done of  
19 past experience within each engineering discipline,  
20 which resulted in 475 feedback issues to review and  
21 1,175 suggestions for improvement.

22 I'm very interested in that. I would like  
23 to pursue this some more. Where would I go to do  
24 that?

25 MR. YU: In what way you want to pursue



1 that?

2 DR. ROSEN: Well, to know what the 475  
3 feedback issues were, for example, and what had been  
4 done with them. Perhaps the same for the 1,175  
5 suggestions for improvement.

6 At some point I'll fatigue, but at least  
7 I would like to start.

8 MR. YU: Okay. Well, I think we can give  
9 a status report.

10 DR. ROSEN: You must have some  
11 compilation.

12 MR. YU: Yeah, yeah. We have, in fact,  
13 tied into a feedback database, and so certainly they  
14 have been scanned for the applicability, and also, you  
15 know, each of the disciplines would be using that as  
16 part of the design input to make sure that we would  
17 avoid the previous problems.

18 DR. ROSEN: It's a very good start for a  
19 new design, avoiding the problems you know about.

20 MR. YU: Yeah.

21 DR. APOSTOLAKIS: Since we are going to  
22 talk about the information needs, there is a sentence  
23 here that intrigues me. "Reliability of the safety  
24 critical software is demonstrated through trajectory  
25 based random testing."

1                   Would you send me a document to educate me  
2 about this?    I'm sure that you have something  
3 somewhere.  I mean these are really impressive words.

4                   (Laughter.)

5                   CHAIRMAN KRESS:  It's a trajectory.

6                   DR. APOSTOLAKIS:  This is in Section 3.6  
7 of this report by Worthington and Rogers.

8                   MR. SNELL:  Yeah, we can send you that.  
9 It was also done on CANDU 9, and I believe we made a  
10 submission to our own regulatory on that time.

11                   DR. APOSTOLAKIS:  Okay.  So you have  
12 concluded -- I mean, I don't know when we're going to  
13 discuss this.  I mean, the safety system reliability,  
14 you set a target of ten to the minus three.  It says  
15 here years per year.  I don't know what that means.  
16 Probably per year only, right?

17                   MR. YU:  Per year.

18                   DR. APOSTOLAKIS:  Years per year?

19                   MR. YU:  It is one.

20                   DR. APOSTOLAKIS:  No, there is an S.

21                   And then you say that this was chosen to  
22 insure that the likelihood of a larger lease is  
23 extremely low and all of that.  I mean, this is a very  
24 interesting application.

25                   MR. YU:  It's part of the regular

1 philosophy to set a reliability target and for  
2 operational reactor, they have to demonstrate the  
3 reliability of the system to meet that target. of ten  
4 to the minus three.

5 DR. APOSTOLAKIS: This ten to the minus  
6 three comes from the regulator?

7 MR. YU: Yes.

8 DR. APOSTOLAKIS: Is it also true that if  
9 you show that your reliability is ten to the minus  
10 five you don't get any credit for that, that it stays  
11 at ten to the minus three because the regulator says  
12 so?

13 See, I don't understand --

14 MR. YU: No, no, no, no, no, no.

15 DR. APOSTOLAKIS: No? I remember vaguely  
16 reading something like this years ago, that you cannot  
17 claim more credit than we allow you to claim.

18 MR. YU: Oh, yes, the system has to  
19 demonstrate that it meets that minimum reliability  
20 limit.

21 DR. APOSTOLAKIS: Right.

22 MR. YU: Obviously you need to achieve  
23 better than that before you can show that your testing  
24 has demonstrated the reliability requirement has been  
25 met.

1 But in safety analysis, especially in  
2 dealing with fuel failures, you cannot credit each of  
3 the shutdown systems to be more reliable than the ten  
4 to the minus three. I think that's maybe what you're  
5 referring to.

6 DR. APOSTOLAKIS: Anyway, I'd like to see  
7 more information on this, how you implement it, if  
8 there is any. Otherwise maybe this is it.

9 MR. YU: Well, I think we can show you  
10 what needs to be done. We need to do operational  
11 testing of the control logic, as well as the hardware,  
12 to make sure that the failure rate is demonstrated.  
13 This is really through the testing.

14 DR. APOSTOLAKIS: Now, I have a question  
15 on something else. I managed to download your policy  
16 on human factors, and it's very interesting that  
17 essentially what it says is do a good job.

18 Is there another document that tells you  
19 how to do a good job? Because we have big reports  
20 that give guidance to the licensees regarding human  
21 factors, and this is really impressive. It's only two  
22 bullets. It says, "Take into account human factors  
23 that could impact upon the Commission's mandate for  
24 protection."

25 Well, how do you do that?

1 MR. YU: For us, certainly there are  
2 inter-Canadian regulatory guidelines, and for our  
3 design we have established an engineering human  
4 factors plan, and from the plan we have established  
5 design guides.

6 DR. APOSTOLAKIS: So there is a regulatory  
7 guide that implements this policy or you don't use it  
8 where it's a regulatory guide?

9 MR. YU: Well, there's a regulatory  
10 document for guidelines. You're guiding what is  
11 needed, and we have an entering (phonetic) human  
12 factors plan for the implementation as well as the  
13 more detailed entering practices that are needed in  
14 order to demonstrate that they are met.

15 It's a different framework, but the ideas  
16 are the same. For designers, you know, certainly they  
17 have the entering guide they use for the day-to-day  
18 design, as well as a section in each of the design  
19 documents that are addressed.

20 DR. APOSTOLAKIS: At some point somebody  
21 will tell us what the major differences between the  
22 two regulatory systems are so we don't have to figure  
23 them out ourselves? You're using the same words like  
24 defense in depth and all of that, but are there any  
25 major challenges somewhere there that we do and you

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1 don't do or you do and we don't do?

2 MR. YU: I believe the challenges are very  
3 similar.

4 DR. APOSTOLAKIS: Get the core damage  
5 frequency below ten to the minus five, right?

6 MR. YU: That's right.

7 CHAIRMAN KRESS: I hate to interrupt this.  
8 Patience with us. We were scheduled for a break at  
9 10:30, and we're a half hour behind schedule. Rather  
10 than go to the next item on the agenda, I suggest we  
11 take a break now and be back in about 15 minutes.

12 DR. APOSTOLAKIS: Twelve o'clock.

13 CHAIRMAN KRESS: No, no, 10:45. I'll give  
14 you an extra few minutes. Be back at 10:45.

15 (Whereupon, the foregoing matter went off  
16 the record at 10:25 a.m. and went back on  
17 the record at 10:45 a.m.)

18 CHAIRMAN KRESS: We will move to Roman  
19 numeral five on the agenda, ACR pre-application scope,  
20 rationale and expectations.

21 Vince Langman.

22 MR. LANGMAN: Hi. I'm also the designated  
23 catch-up player because I think we can actually --

24 CHAIRMAN KRESS: That will be helpful.  
25 Thank you very much.

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1 MR. LANGMAN: We can go through this  
2 presentation fairly quickly.

3 I've also been asked. There was one point  
4 that I thought was fairly important that wasn't quite  
5 right. The free containment volume is actually 48,000  
6 cubic meters, not 58. Okay?

7 Also, I'd like to take this opportunity to  
8 introduce three other people that we brought with us.  
9 Nick Popov, if you could just stand up in the back.  
10 He's actually the licensing manager for the ACR effort  
11 in Canada, but he has also been very key on the  
12 technical side with regards to the PIRT exercise  
13 that's going on with the NRC at the current time and  
14 also on the computer code validation side of the  
15 house.

16 And Al Stretch, who is ACL's expert on  
17 codes and standards and safety design philosophy.

18 And last but not least Robert Ion, who is  
19 my right hand and left hand, and is one of the people  
20 who makes all of this exchange of information  
21 possible, which has been, as you'll see, although I'll  
22 flip through it very quickly, has been an extensive  
23 amount of information exchange in what I consider to  
24 be a reasonably short period of time.

25 So I was asked to talk fairly briefly

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1 about how do we come up with this pre-application  
2 scope, and what were some of our expectations, and as  
3 Laura mentioned earlier, we started the pre-  
4 application review in mid-2002 and kind of wrapped it  
5 up at the end of the summer of 2003.

6 We had a pretty good idea from our  
7 perspective as to what some of the CANDU specific  
8 focus topics needed to be. Through discussion with  
9 the NRC staff, we actually added one, which was the  
10 actual confirmation of void reactivity.

11 One of the big feedback items that has  
12 been mentioned is from the CANDU 3 days. It was very  
13 clear coming in this time that a positive voice  
14 coefficient was a nonstarter, and so we incorporated  
15 that feedback right from the beginning.

16 We've had extensive familiarization  
17 meetings, have submitted a number of large tomes  
18 related to the technology base and the design, and  
19 we've started the process of responding to the staff's  
20 request for additional information.

21 As Laura also mentioned, we sort of  
22 morphed into Phase 2 September of this past year and  
23 expect to hopefully finish Phase 2 by September of  
24 2004. We have a pretty aggressive schedule of  
25 additional technical meetings on the key focus topics

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1 especially, and I'll mention what those key topics  
2 are. That's really what we're here to provide some  
3 more technical information on.

4 We are participating; ACL is participating  
5 to the fullest extent on the NRC PIRT meetings that  
6 are being held, the subpanel work that's being done on  
7 reactor analysis, severe accidents, and thermal  
8 hydraulics.

9 There are a number of additional reports  
10 that we are also intending to deliver, and we expect  
11 that there will be a lot more requests for information  
12 from both the staff and, as was evident from before  
13 the break, from the ACRS members as well.

14 So it was pretty simple. There are a  
15 number of CANDU specific aspects of the ACR that are  
16 not easily addressed or not addressed at all by the  
17 current NRC regulations, and so what we really went  
18 after in terms of key focus topics were basically  
19 things in the design that if the NRC don't like them  
20 or can't handle them -- probably "don't like them" is  
21 a better phrase -- then there's no sense in going  
22 forward.

23 If you tell us that, you know, zirc-  
24 niobium is not a good pressure tube material and  
25 you've got to make it out of something else, we'll say

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1 thank you and we'll go home. I don't think that will  
2 be the case, but you know, we have to be clear. There  
3 are certain aspects of the design that aren't  
4 currently handled.

5 There are also certain issues as well that  
6 have prohibitively large monetary or schedule impacts.  
7 For example, computer codes and the extent of  
8 validation. If you were to say, well, no, we really  
9 need a fully validated TRAC or RELAP model for the  
10 CANDU system and that's what we want you to use in  
11 your safety analysis, that would be a pretty major  
12 schedule and monetary effort on ACL's part, and  
13 certainly there has been a lot of code validation and  
14 development work done over the decades at ACL specific  
15 to CANDU.

16 So these are a matter of record. So --

17 DR. APOSTOLAKIS: So I don't understand  
18 this. What do you think the NRC staff should do when  
19 it comes to points that may be prohibitively large  
20 monetary expenses?

21 MR. LANGMAN: If you'll give me a minute,  
22 I'll get to that. We state it pretty clearly.

23 DR. APOSTOLAKIS: You can even have two.

24 MR. LANGMAN: Okay. For those who know  
25 me, that may not be enough.

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1 (Laughter.)

2 MR. LANGMAN: I don't intend to go through  
3 all of these. They are a matter of record. The key  
4 ones that we have come prepared to discuss are the  
5 Class I pressure boundary, computer codes and  
6 validation adequacy, the whole concept of on power  
7 fueling, including the fuel design and acceptance of  
8 the fuel design.

9 That actually, I think, will be broken out  
10 into a separate key focus topic, albeit it brings the  
11 total to 13, but we'll do that anyway, and  
12 confirmation of the negative void reactivity.

13 DR. ROSEN: Are you implying that there's  
14 some degree of contentiousness about these three? For  
15 instance, on power fueling, is there some view that  
16 you have that the staff is against on power fueling as  
17 a matter of religion or --

18 MR. LANGMAN: Oh, no, no. It's more the  
19 fact that it is definitely different, and we have to  
20 show you what it's all about and there are no, I don't  
21 think, any real requirements in the current Code of  
22 Federal Regulations that deal with fueling on power,  
23 and I think it's more of the fact that one needs to  
24 come up with those.

25 I'm not saying that these are key because

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1 we think they can't be solved. I'm saying they're key  
2 because they have to be solved. Okay?

3 There are certain things that are nice to  
4 have on some of the focus topics, but if we don't get  
5 those, then we can go ahead anyway, but there are  
6 certain areas like roll joints, which is one of my  
7 favorite ones. I mean, roll joints are not part of  
8 the current Class I accepted kind of process, but  
9 they're absolutely critical to the whole concept of  
10 CANDU and the fact that you can change channels out  
11 during operation, you know -- not during operation,  
12 but during a maintenance effort.

13 But not that we expect we have to, but it  
14 is something that's rather key to the design.

15 DR. ROSEN: Well, no, you do expect to do  
16 it once in the life of --

17 MR. LANGMAN: Yes, at 30 years we change  
18 out the whole core.

19 So this was just meant to impress people  
20 with the fact that we did have a lot of  
21 familiarization meetings in Phase 1. The NRC staff  
22 stalwartly braved the Canadian winter in Chalk River  
23 in December 4th and 5th, and we dutifully had a good  
24 snowstorm for them.

25 CHAIRMAN KRESS: At least you didn't have

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1 any mosquitoes.

2 MR. LANGMAN: No, no. That was supposed  
3 to be in White Shell.

4 We, also, had a meeting on the details of  
5 the RD-14(m) results in June. That was when the  
6 mosquitoes were supposed to come in. Unfortunately it  
7 was a very dry summer in Manitoba, and so there  
8 weren't that many.

9 CHAIRMAN KRESS: When we have dry summers  
10 down here, it makes the mosquitoes worse.

11 MR. LANGMAN: Ah, okay. Anyway, we had a  
12 whole series of meetings and around about the end of  
13 the summer, as I mentioned last year, we sort of  
14 jointly decided that these big, familiarization  
15 meetings had served their purpose, and we were now at  
16 a stage where we wanted to get the specific technical  
17 experts at ACL together with the specific reviewers on  
18 the NRC side and get into more detail.

19 There is a list here just for your  
20 information of the type of information that has been  
21 submitted during pre-application. I should note that  
22 we have provided any of the computer codes that people  
23 want to look at. We've provided the source versions  
24 of these codes and input decks, and there has been how  
25 one actually utilizes these thermal hydraulics codes,

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1 and there's a physics code similar meeting coming up  
2 in February back in --

3 DR. APOSTOLAKIS: Well, all of these  
4 thermal hydraulic codes and basic structure are very  
5 much the same, aren't they?

6 MR. LANGMAN: Yeah, I would think so. I'm  
7 a fuel guy more than a thermal hydraulics person, but,  
8 yes. But every code has its idiosyncracies, and we're  
9 just trying to make the familiarization process  
10 faster.

11 DR. FORD: Vince, just to make sure I  
12 understand, on the previous, two previous, when you  
13 say the documentation given to the staff, that  
14 documentation is enough to back up the definitive  
15 statements made in these documents? For instance, the  
16 materials, there's a statement saying there will be no  
17 problem with the late hydride cracking or words to  
18 that effect. There had been documentation given to  
19 the staff to back up that statement?

20 MR. LANGMAN: For example, on the pressure  
21 tube side, we provided a rather large document on sort  
22 of everything you've wanted to know about pressure  
23 tubes but were afraid to ask. It was done in a very  
24 technology base oriented way. So it was kind of a lot  
25 of the R&D related to the understanding of pressure

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1 tubes.

2 I think what's coming up and what is still  
3 required is for us to also provide how we think one  
4 could actually review and accept pressure tubes like  
5 the way we do in Canada in the United States. We  
6 haven't got to that tough part yet, but we are working  
7 on it.

8 DR. FORD: Okay, okay.

9 MR. LANGMAN: And it's intended that that  
10 type of information if it isn't provided prior to our  
11 submission of design certification, it will be  
12 included either by reference or will be included in  
13 our design control document that we submit for design  
14 certification.

15 So we do recognize that we have to provide  
16 that kind of information. I'd say we're maybe a  
17 little over half-way to two-thirds of the way there  
18 because the technology base, one of the focus topics  
19 that seemed kind of odd was the technology base. We  
20 did want to take an appropriate amount of time to show  
21 the amount of research and development that is behind  
22 the statements that are made, and I think, you know,  
23 ACL is a bit unique in that regard as a reactor vendor  
24 because they also are the people that are responsible  
25 for the nuclear lab in Canada at Chalk River and White

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1 Chalk.

2 And so there is a large technology basis  
3 there, and we wanted to make sure that everyone  
4 understood what was available.

5 These are just more of the things that  
6 we've provided. We have provided a rather lengthy  
7 comparison on the quality assurance side. We've also  
8 gone through an initial assessment of the generic  
9 safety issues. That's more a screening in terms of  
10 which ones may be applicable to the ACR, and that has  
11 been provided to the staff as well.

12 So what do we expect out of all of this?  
13 Well, we certainly hope that the staff will identify  
14 whether there are any impediments to actually  
15 licensing the ACR in the U.S. not only on the specific  
16 topics that we've chosen, but if we have, indeed,  
17 missed some, we would assume that they would talk to  
18 us about those as well.

19 We're looking to have success paths  
20 identified for any unresolved focus topics that occur  
21 or that may not be resolved during pre-application,  
22 and I think Laura stated it correctly that it's not  
23 expected that we'll be able to come to a regulatory  
24 resolution on a lot of these pre-application focused  
25 topics, but we do want to make sure that we have a

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1 common understanding of how we can get from there to  
2 here.

3 MR. SIEBER: Maybe I could ask a question  
4 that I should have asked 60 seconds ago.

5 MR. LANGMAN: Sure.

6 MR. SIEBER: As far as QA is concerned,  
7 does AECL use the Appendix B type of QA or ISO 9000  
8 series QA?

9 And if you use ISO 9000, would that be  
10 acceptable?

11 MR. LANGMAN: I'm not as familiar with  
12 ACL's current status on ISO 9000. So I'll ask Stephen  
13 if he knows about that in a minute.

14 MR. SIEBER: Okay.

15 MR. LANGMAN: But certainly ACL uses a  
16 series of standards, the Canadian Standards  
17 Association that have been compared to the U.S.  
18 requirements, and actually on the QA side even though  
19 it hasn't been listed as a focus topic, you may have  
20 noticed there was actually a familiarization meeting  
21 for about two --

22 MR. SIEBER: Yes, there was.

23 MR. LANGMAN: -- and a half days in  
24 December, and it's my understanding that there has  
25 been considerable progress made between the staff, the

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1 NRC staff, on the QA side with our staff, and although  
2 I'm not a QA guru, I think it's fair to say my  
3 feeling is that there is a lot of meeting of the minds  
4 and it looks like it's not going to be a major issue.

5 MR. SIEBER: Well, perhaps when it's the  
6 staff's turn they could address that same question in  
7 a sentence or two.

8 MR. YU: Stephen Yu here.

9 The only thing I can add is, yes, we  
10 follow the CAC standard, but, on the other hand, we  
11 also have seeked (phonetic ISO 9002 registration, and  
12 so we have been subjected to that kind of audit, and  
13 so we did meet the requirements.

14 So the basis of our QA menus and so on are  
15 based on the standard that we have subject to other  
16 audits.

17 MR. SIEBER: Okay. Thank you.

18 MR. LANGMAN: I think I've also alluded to  
19 the third bullet, which is the assessment of the  
20 completeness of our R&D program and technology base.  
21 We do have tests specific to the ACR actually in  
22 progress and over the next couple of years, and as  
23 well as a rather extensive R&D program that supports  
24 the sort of CANDU specific aspect of the ACR design.

25 And last, but not least, we were hoping

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1 that we would be able to get some estimate of the cost  
2 and schedule that the staff field would be required  
3 for actually performing the design certification  
4 review of the ACR by the end of pre-application.

5 This is an expectation, but it's in  
6 recognition of the fact that there is a concurrent  
7 pre-licensing process going on on the ACR both in  
8 Canada and in the United States, and this is in our  
9 mind an excellent opportunity for synergy between two  
10 mature and knowledgeable regulators, and so we have  
11 tried to set this up in a way that there are common  
12 major documents for review, similar time frames for  
13 those reviews, and we're hoping that basically this  
14 will lead to what I refer to as a common North  
15 American technology, technical basis for licensing the  
16 ACR in Canada and the U.S.

17 We do recognize that the nature of the law  
18 in Canada and the U.S. require that certain things may  
19 be treated differently, but we believe it's very  
20 important that both regulators have a common  
21 understanding of what the issues are and what the  
22 actual technical basis and what the design is so that  
23 when you apply those separate requirements, they're  
24 applied to a common understanding of what the machine  
25 actually looks like and is.

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1                   And that's basically it for my preamble on  
2 that. I have a very brief introduction to the key  
3 focus topics.

4                   Class I pressure boundary design. Some of  
5 these I was a little concerned when I wrote these, but  
6 I decided that we wanted to make sure that it was very  
7 clear what we were looking for from the NRC. So they  
8 sound a bit presumptuous, but here goes.

9                   I mean, for this particular issue we're  
10 looking for the staff to accept the principal design  
11 features of the pressure boundary. We don't say how,  
12 but we're looking for them to accept them somehow.

13                   The use of zirc-niobium pressure tubes or  
14 the use of zirc-niobium as pressure tube material --

15                   DR. SHACK: So you're not planning on  
16 running off and getting a code case, for example, from  
17 the ASME? That's not part of the game plan?

18                   MR. LANGMAN: That is not part of the game  
19 plan, neither for roll joints or closure plugs, 403  
20 stainless steel end fittings and fueling machines as  
21 components of a Class I pressure boundary.

22                   MR. SIEBER: Well, actually your pressure  
23 boundary is an ASME 8 class pressure boundary?

24                   MR. YU: For a fuel machine, the boundary  
25 of the head that handles the fuel, which is connected

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1 to the fuel channel, are Class I.

2 MR. SIEBER: Okay. But the pressure  
3 tubes, the steam generators, all of those headers and  
4 all of that. It seems to me I read someplace where  
5 you're using the ASME code as the code of record.

6 MR. YU: Yeah, that's correct.

7 MR. SIEBER: Okay.

8 MR. LANGMAN: We use ASME wherever we can  
9 in our process, and when CANDU specific issues arise,  
10 that tends to be where the Canadian Standards  
11 Association standards have been developed and are in  
12 use.

13 The of note part is just with respect to  
14 what we've actually submitted and some notes to make,  
15 and one of them is we have provided the CSA standards  
16 related to the use of these materials and components.

17 The fitness for service guidelines, there  
18 was a question earlier with regards to how do we  
19 monitor the fitness or the pressure tubes. There is  
20 actually a rather extensive assessment that's  
21 performed on an ongoing basis to insure that the  
22 pressure tubes are fit for service, information on  
23 pressure tube inspection or the fact that we have  
24 rather extensive pressure tube inspection technology,  
25 and pressure tubes really are an area.

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1 I was talking to Mark Leger at the break,  
2 and we were trying to do a rapid mental calculation,  
3 which is always a danger, about how many person-years  
4 we've actually spent in Canada on pressure tubes, and  
5 we place it possibly in excess of 1,000 person-years,  
6 I mean, in terms of research and development. I mean,  
7 there has been a lot of work done over the last four,  
8 five decades on pressure tubes. They're an integral  
9 part of our design concept, and they were something we  
10 knew right from the beginning we had to understand  
11 very well.

12 And so there is a lot of information, and  
13 it's actually why this is the number one focus topic,  
14 because I think this is an absolutely key area, and it  
15 is also one that there's so much information that it's  
16 a challenge to get through it all to come up with the  
17 types of requirements that would be needed in the U.S.  
18 to allow this to happen.

19 DR. WALLIS: So these are your desired  
20 outcomes.

21 MR. LANGMAN: Yes.

22 DR. WALLIS: Does the staff agree that  
23 these are reasonable outcomes to AMAT at this stage in  
24 the process and in a reasonable period of time?

25 MS SOSA: I'd like to address that.

1 Belkys Sosa, the project manager for the ACR at site.

2 Their use of "the staff accepts" is always  
3 something that we had several discussions over, and I  
4 think what they are expressing here is the desired  
5 outcome, big picture. When we're talking about pre-  
6 application review, we're simply going to identify  
7 showstoppers; technical areas that will need to be  
8 looked at in more detail; essentially provide feedback  
9 for them in time to incorporate in their design  
10 certification obligation.

11 We don't expect to resolve these safety  
12 issues on any of these focus topics in the next year.  
13 This stuff needs to come up to speed on familiarizing  
14 themselves not just with CANDU technology, but ACR  
15 specific designs.

16 DR. WALLIS: So rather than accepting,  
17 you're going to not reject.

18 MS. SOSA: Yes.

19 (Laughter.)

20 DR. WALLIS: You don't give them the  
21 rubber stamp that says, "We accept all of these  
22 things." You're just saying, "We have not rejected."

23 MS SOSA: Yes, and we will also hopefully  
24 identify the issues that will need to be resolved. I  
25 think that's a big plus.

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1 DR. WALLIS: Yes.

2 MS. SOSA: The pass-forwards he refers to  
3 it.

4 MR. LANGMAN: I would hope that the  
5 success path could be defined pretty clearly because  
6 at the end of the day, you know, two thirds of the way  
7 through design certification and X tens of millions of  
8 dollars or hundreds of millions of dollars later, it's  
9 like, "Oh, by the way, we can't get our head around  
10 two and a half percent niobium," I'm going to have to  
11 fall on my sword somewhere, you know, because that's  
12 part of the reason to focus on these, was to sort of  
13 try to wrestle with the hardest issues right up front  
14 to see if there really is something that is a  
15 showstopper rather than assuming we'd be able to work  
16 our way through everything, quite frankly.

17 Focus topic number three, computer codes  
18 and validation adequacy. Since CANDU 3, there was  
19 about a six-year integrated effort in Canada involving  
20 all the Canadian utilities and ACL with regards to  
21 formal validation of our computer codes used in safety  
22 analysis, and we've been sharing with the NRC staff  
23 the outcome of those assessments, and basically we're  
24 looking to have the staff accept the computer codes as  
25 fit for purpose for analyzing the ACR 700, which is a

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1 little different than saying they're just certified.

2 Like we really want to focus, to begin  
3 with, on do they agree that they're put for purpose  
4 for the actual analysis of the ACR 700 as opposed to  
5 CANDU reactors in general. Okay?

6 CHAIRMAN KRESS: If we're talking about,  
7 let's say, thermal hydraulics codes, is your approach  
8 going to be an Appendix K approach or a best estimate  
9 approach, if you know what the difference between  
10 those two are.

11 MR. LANGMAN: Oh, yeah. What we have  
12 currently in Canada is something we call limit of the  
13 operating envelope approach, and my understanding is  
14 there is a DOE funded project ongoing currently with  
15 INEEL that is actually evaluating our limit of the  
16 operating envelope approach to LOCA analysis against  
17 Appendix K, evaluation models.

18 We have done uncertainty analysis in the  
19 past and best estimate plus uncertainty analysis, but  
20 the intention was not to go that route for this  
21 particular application.

22 So I guess the most direct answer I can  
23 give you is that we're probably a little bit in the  
24 middle.

25 DR. WALLIS: I wish you would go to

1 realistic, and do it right and show us how it should  
2 be done.

3 MR. LANGMAN: Point taken.

4 DR. RANSOM: Does the plan include  
5 submitting your computer codes to the NRC for their  
6 review?

7 MR. LANGMAN: Oh, yes. Actually as part  
8 of pre-application we've submitted the major work  
9 horse codes, the CATHENA code, which is our system  
10 thermal hydraulic code, and the physics code sweep  
11 (phonetic). As part of the fuel design review, we'll  
12 also be submitting the fuel codes that we use in  
13 analysis, as well as severe accident codes eventually,  
14 but yes.

15 To begin with though we focused on thermal  
16 hydraulics and physics and felt that if we could work  
17 out sort of the process for review and what the staff  
18 need to see and what's helpful to them with those two  
19 code sweep or the one code and the other code sweep,  
20 then we could apply that to the other codes and make  
21 it a bit more of an efficient process rather than  
22 trying to hit them with all ten or 12 codes at once,  
23 but the intention is yes.

24 DR. WALLIS: Well, I think to go farther  
25 in what I just said, I mean, if you try to make your

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1 ACR fit something like Appendix K, there are all kinds  
2 of hidden conservatisms and things in Appendix K which  
3 are really specific to the designs that we have in  
4 this country.

5 MR. LANGMAN: Yeah. We don't have a  
6 reflood philosophy.

7 DR. WALLIS: Right, right.

8 MR. LANGMAN: Yes, that is true.

9 Focus topic number eight, the third key  
10 focus topic on power fueling, and I've got in brackets  
11 "including fuel design." I believe this will actually  
12 become a separate key focus topic. I think both the  
13 staff and us have recognized that this is a pretty  
14 major item, as well, to actually review and approve  
15 the CANDU fuel design, the ACR fuel design, and it's  
16 really the fact that our fuel design is different.

17 You know, just when you compare the  
18 physical size of a PWR fuel assembly to a CANDU fuel  
19 bundle, and we do have a full mock-up of CANDU fuel  
20 bundle for ACR and the pressure tube and calandria  
21 tube is somewhere in One White Flint, right? It's not  
22 in Two. So it is around. You have one in your  
23 possession right now if you ever want to look at it.

24 DR. WALLIS: Pick it up.

25 MR. LANGMAN: Yeah, yeah, even when it's

1 loaded with fuel, it's about 50 pounds. I won't  
2 steal Peter Boczar's thunder, but he's going to talk  
3 a bit more about the fuel design.

4 You know, obviously we have had extensive  
5 successful experience with the various fuel designs  
6 that have been developed over decades. There's been  
7 a whole lot of effort put into CANDU fuel as well,  
8 probably a little less on pressure tubes, but on a  
9 similar order of magnitude, and we have had on CANDU  
10 fuel extensive experience with on power fuel, and so  
11 we don't expect any problems in that area as well, but  
12 Jullian Millard will be addressing that more fully in  
13 a moment.

14 And last but not least, the confirmation  
15 of the negative void reactivity. This was one where  
16 I quickly learned that a lot of the staff are from  
17 Missouri. I figured when we pulled these together,  
18 you know, the void reactivity is going to be negative.  
19 So that's not really a key focus topic because, darn  
20 it, you know, it's going to be negative.

21 And basically it was mentioned that this  
22 would probably be a very good idea to have this as a  
23 key focus topic to make sure that we do confirm that  
24 it is a negative void reactivity. We take that very  
25 seriously.

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1                   There are a number of R&D programs  
2 underway to provide ACR specific validation for the  
3 physics code sweep that will help with the technology  
4 basis for this, and Peter Chan will be walking you  
5 through a bit about how we came to a negative void  
6 coefficient.

7                   So with that, oh, one last thing. This is  
8 not a key focus topic, but we thought it was an  
9 appropriate time to talk a bit about our PRA  
10 methodology. My understanding which is really sketchy  
11 on this is that we are -- our methodologies are very  
12 similar to the U.S. approach, but I'll leave that for  
13 Raj Jaitly to further expound upon.

14                   And we --

15                   DR. APOSTOLAKIS: I'm surprised it's even  
16 a focus topic. I mean, what's so special about it?

17                   The others I can understand, but this one  
18 doesn't seem to me to belong here.

19                   MR. LANGMAN: You know, you could be right  
20 actually on that one. The more we think about it, I  
21 mean, we are looking at the sort of frequency goals,  
22 ten to the minus five, ten to the minus seven, but we  
23 felt -- well, okay.

24                   DR. ROSEN: Even trees, fault trees.

25                   MR. LANGMAN: Yeah.

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1 DR. WALLIS: That's not the problem.

2 DR. ROSEN: Success criteria scenarios,  
3 all that stuff.

4 MR. LANGMAN: Yeah, Raj is nodding his  
5 head.

6 DR. ROSEN: What's new?

7 MR. LANGMAN: Well, we'll hear.

8 DR. WALLIS: Well, the problem is the  
9 indefinable to some folks measure of quality of the  
10 PRA.

11 DR. APOSTOLAKIS: Yeah, but that's not the  
12 special focus issue here. I mean, there's no  
13 difference --

14 DR. WALLIS: Well, there has to be  
15 agreement about how good it has to be.

16 MR. SIEBER: You have different  
17 phenomenology.

18 MR. LANGMAN: Yes. That was the one  
19 aspect of this, was the actual different severe  
20 accident phenomenology, and that was a part of like  
21 the actual focus. A lot of the focus of the  
22 familiarization meetings was more on the actual  
23 technology basis for understanding the phenomena  
24 associated with severe accidents.

25 MR. SIEBER: Well, required.

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1 MR. LANGMAN: The actual methodology of  
2 doing the analysis, I guess.

3 MR. SIEBER: It requires the adaption of  
4 the results of severe accident codes and thermal  
5 hydraulics codes in PRA terms in order to make it  
6 realistic, and that's no easy thing to do.

7 DR. WALLIS: Well, there may be more model  
8 uncertainty, for instance, or less, less model  
9 uncertainty because --

10 MR. SIEBER: Yeah, but you have to be able  
11 to --

12 DR. WALLIS: -- particular codes and  
13 physical events.

14 MR. SIEBER: You have to be able to define  
15 that in order to know what the uncertainty really is.

16 CHAIRMAN KRESS: I would guess one of the  
17 issues would be what kind of fission product source  
18 term is involved in the various sequences.

19 DR. APOSTOLAKIS: Yeah, but it doesn't  
20 sound to me like it's at the same level as the Class  
21 I pressure boundary design.

22 CHAIRMAN KRESS: No, I don't think so.

23 MR. LANGMAN: Oh, that's why it's not  
24 actually a key focus topic.

25 CHAIRMAN KRESS: A focus topic, not key.

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1 DR. APOSTOLAKIS: Ah.

2 MR. LANGMAN: Sorry. No, it's not a key  
3 one.

4 DR. SHACK: It's not safety related. It's  
5 just the extent to which you meet goals.

6 DR. ROSEN: It's nice to put it up there.  
7 The ACRS has had more than a passing interest in the  
8 PRA technology.

9 DR. SHACK: So what is the meaning now of  
10 going from one to three to eight and from nine to 11?  
11 There were others that were settled or --

12 MR. LANGMAN: No. There were other topics  
13 that were part of a previous list.

14 CHAIRMAN KRESS: If you go on the previous  
15 list, there's about 11 or 12 topics. A number of them  
16 aren't key, and he just picked out the ones that were  
17 key and gave them the same number.

18 MR. LANGMAN: So without further ado, I  
19 guess Mark Leger is the first person up.

20 Thank you.

21 DR. WALLIS: So you've really caught up in  
22 time, haven't you?

23 MR. LANGMAN: That's my job.

24 CHAIRMAN KRESS: You did good.

25 DR. WALLIS: So let's see. Where are we

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1 now?

2 MR. LEGER: Good morning. I'm Mark Leger,  
3 and I'm going to be talking about the Class I pressure  
4 boundary.

5 I've outlined the talk here. I wanted to  
6 talk about some of the major features of the pressure  
7 boundary. I'm going to talk a fair bit about our  
8 CANDU experience actually. I'll say some things about  
9 leak before break and how this fits into our  
10 philosophy for pressure tubes, and then I'm going to  
11 talk about some of the fuel channel standards on  
12 pressure tubes and fittings, some of the issues with  
13 regard to channel closures for on power refueling and  
14 a few words about inspection and material  
15 surveillance.

16 So in terms of the pressure boundary  
17 features of the ACR, as was mentioned just a few  
18 minutes ago, with regard to the piping valves and  
19 pressure vessels, all of these are designed to the  
20 ASME code, Section 3 code, and the feeder pipes as  
21 well.

22 We've got these multiple, small diameter  
23 pipes that join the headers in the fuel channels.  
24 They're also designed to the same standard, ASME  
25 Section 3, NB.

1 DR. WALLIS: Does this include design for  
2 inspectability?

3 MR. LEGER: We are --

4 DR. WALLIS: Because you've got this  
5 forest of feeder tubes. You have to get devices in  
6 there to inspect for whatever may be going on.

7 MR. LEGER: We are considering inspecting.  
8 How inspection will be done for these, as was  
9 mentioned before with regard to the dissimilar metal  
10 weld, the location of this weld is an issue with  
11 regard to our ability to be able to do inspection.

12 MR. SIEBER: Well, you're just inspecting  
13 the joint. So the complexity of all of these tubes  
14 going to the header, you really are only looking at  
15 two places, which is where it connects to the pressure  
16 tube and where it connects to the header.

17 MR. LEGER: Well, in some cases there will  
18 be other welds within the system.

19 MR. SIEBER: Oh, within the tube? Yeah.  
20 Well, that does make it tough.

21 MR. LEGER: But these are low risk welds.  
22 So as you can see, we've got the headers at the top  
23 here and all of these feeder pipes that go down and  
24 join onto the end fittings, but all of the components  
25 at the top here are all right down until you get to

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1 the fuel channel, it's all designed with ASME  
2 standards.

3 DR. WALLIS: Is all of this enclosed in  
4 insulation of some sort?

5 MR. LEGER: Yes. There is an insulation  
6 cabinet.

7 DR. WALLIS: Stuffed in or is there a box  
8 that fits --

9 MR. SIEBER: There's a box.

10 MR. LEGER: It's basically boxed in. At  
11 least it is in the current CANDU 6.

12 DR. ROSEN: When you get a leak out there,  
13 you don't know where it's coming from. It's in the  
14 box someplace.

15 MR. SIEBER: Well, you take the box off.

16 DR. ROSEN: In the header. You get one of  
17 these tubes leading from the header to the face of the  
18 machine. That leak will just appear in the box,  
19 right?

20 MR. LEGER: It would appear in the box,  
21 yes.

22 MR. SIEBER: Yeah, I would think a visual  
23 examination there would be difficult. You can't see  
24 every place because there's a lot of obstructions  
25 there.

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1 DR. FORD: Somewhere in one of the  
2 documents, I think one of the documents that was sent  
3 to us before this meeting, this question of  
4 inspectability came up, and it was admitted, I guess,  
5 that there are areas where you cannot inspect. You  
6 just physically cannot inspect it.

7 Has there been analysis done of the  
8 consequence if you have a failure in one of these  
9 complex piping geometries as to whether you have just  
10 got to inspect it or what?

11 MR. LEGER: Well, the single feeder  
12 covered by a safety analysis --

13 MR. SIEBER: That's one of your design  
14 bases.

15 MR. LEGER: Yes, that's right.

16 MR. SIEBER: You're supposed to be able to  
17 tolerate that with a fuel main.

18 DR. FORD: So, in other words, you've  
19 specifically designed this spaghetti of tubing such  
20 that those critical piping areas can be inspected.

21 MR. LEGER: That's right.

22 DR. FORD: Is that true?

23 MR. LEGER: That's right. That's what we  
24 would like. That's what we're trying to achieve.

25 DR. FORD: And those that you can't

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1 inspect, you say, no, never mind.

2 MR. LEGER: That's right.

3 DR. FORD: Is that right?

4 MR. LEGER: That's the goal of the detail  
5 design.

6 MR. SIEBER: That would be a goal.

7 DR. ROSEN: That means that clearly a 90  
8 degree bend, just a 90 degree bend has got to be a  
9 non-risk significant --

10 MR. LEGER: That's right. We would judge  
11 it to be non-risk significant. It would be low --

12 DR. ROSEN: Because you can't possibly  
13 inspect every 90 degree bend.

14 MR. LEGER: That's right.

15 DR. FORD: And that's why you're opting to  
16 go to stainless steel bends? These are the cold form  
17 bends, and presumably you will have erosion/corrosion  
18 at those

19 MR. LEGER: Any bends that are  
20 sufficiently small radius would be stress relieved.

21 DR. SHACK: Okay. Let me come back here  
22 again. If I design these feeders to the ASME code  
23 standards and I have seven welds per feeder, you're  
24 going to go for a risk informed inspection plan then  
25 rather than a standard ASME code inspection? That's

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1 how you're going to get around the seven welds?

2 MR. LEGER: That's what we would like to  
3 do.

4 DR. SHACK: Okay. That's sensible enough.

5 MR. LEGER: Yes.

6 DR. ROSEN: Well, if it's good enough to  
7 do for operating reactors.

8 DR. SHACK: Well, it's not quite ASME in  
9 the usual sense.

10 DR. ROSEN: Well, only in that we didn't  
11 do that when we built our reactors. We did it after  
12 the fact.

13 DR. APOSTOLAKIS: Is a risk informed  
14 approach acceptable in Canada?

15 MR. LEGER: We haven't been using a  
16 detailed risk informed approach for the inspection of  
17 the -- we have a standard for inspection that includes  
18 the Class I pressure boundary, and that's the N-285.4,  
19 CSA N-285.4 standard, and it is based on an assessment  
20 of sort of a judgment of the risk of various parts.

21 DR. ROSEN: Well, now, correct me if I'm  
22 wrong. We've got an ASME code, and we've got a system  
23 of code cases, which means if you meet a code case,  
24 you meet the code. And a risk informed inspection is  
25 a code case, correct? An approved code case.

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1           So if you do risk informed inspection  
2 you're meeting the ASME code. I mean, I could be  
3 wrong, but I think that's what it's --

4           DR. APOSTOLAKIS: That means automatically  
5 it's acceptable in Canada?

6           DR. ROSEN: Oh, I don't know about Canada.

7           MR. LEGER: Our inspection is done through  
8 our CSA standard. It does refer in some places to the  
9 ASME in terms of acceptance criteria and so on, yes.

10          MR. SIEBER: But prior to that, there was  
11 always a selection process going on within a ten-year  
12 interval. When you wrote your ISI plan, you would  
13 name all of the welds and then describe places where  
14 you couldn't inspect and seek exemptions from those,  
15 and then through each interval you would take a  
16 certain percentage of those with the goal of at the  
17 time you decommissioned the plant, you have inspected  
18 everything in it, you know.

19          So the risk informed is just another  
20 mechanism for more intelligently choosing the places  
21 to inspect at each interval or each refueling.

22          DR. APOSTOLAKIS: But the regulators have  
23 to agree with that.

24          MR. SIEBER: Absolutely.

25          DR. APOSTOLAKIS: It's more intelligent.

1 DR. ROSEN: The Canadian regulators. Now,  
2 in the U.S. we accept the ASME code and the code  
3 cases. So that has already been done for risk  
4 informed inspections.

5 MR. SIEBER: Well, we accept it through a  
6 review process.

7 DR. APOSTOLAKIS: Yeah, and it's not --

8 MR. SIEBER: -- 55(a).

9 DR. ROSEN: Right.

10 MR. LEGER: Of course, one of the major  
11 differences between --

12 DR. FORD: Oh, I'm sorry. Could you go  
13 back to the previous slide? I think just skimming  
14 through your presentation you don't deal with this  
15 later on.

16 What we understand now is stainless steel  
17 feedwater pipes are welded to the header, which is  
18 carbon steel, 106 presumably.

19 MR. LEGER: There will be an intermediate  
20 weld within the feeder.

21 DR. FORD: Okay.

22 MR. LEGER: That's what we were talking  
23 about, the location of this transition between the  
24 stainless steel and --

25 DR. SHACK: So you will have a stainless

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1 steel stub on the header where?

2 MR. LEGER: No, it would be a carbon steel  
3 stub on the header. That's right.

4 DR. FORD: But the weld from the stainless  
5 steel to the carbon steel presumably will involve a  
6 nickel base butter.

7 MR. LEGER: It would involve --

8 DR. FORD: Of some sort?

9 MR. LEGER: Yes, that's right.

10 DR. FORD: And this is at 325 degrees C.?

11 MR. LEGER: Yes.

12 DR. FORD: Hot side temperature.

13 MR. LEGER: The outlet temperature.

14 DR. FORD: Yeah. What sort of nickel  
15 based alloy will you use?

16 MR. LEGER: I'm not right up on the detail  
17 at this moment. I could get that for you.

18 DR. FORD: Okay, but obviously you're  
19 going to take into account all of the problems we've  
20 had.

21 MR. LEGER: That's right. We won't be  
22 using the IA-182.

23 DR. FORD: Good.

24 MR. LEGER: It will be something akin to  
25 the --

1 DR. FORD: And you mentioned early on  
2 you've got a lot of extensive experience. You do have  
3 a lot of extensive experience in ultimate nickel based  
4 weld alloys, 690-whatever it might be, 152. Well,  
5 152.

6 MR. LEGER: No. In the current CANDUs, it  
7 is an I-82 material that has been used on the inlet  
8 feeders for the flow orifices.

9 DR. FORD: Okay.

10 MR. SIEBER: Well, the design itself for  
11 these, the headers and the feeder tubes is not unique  
12 to the ACR 700; is that correct?

13 MR. LEGER: Well, in the current CANDU  
14 it's all carbon steel.

15 MR. SIEBER: Right. Okay.

16 DR. SHACK: But your document in 4.6 says  
17 they are stainless to carbon steel welds. Are you  
18 telling me that there are none of those now?

19 MR. LEGER: Well, it is a stainless to  
20 carbon steel weld, but the weld material is something  
21 different. That's what Peter's point was.

22 DR. SHACK: Oh.

23 MR. YU: Stephen Yu here.

24 The feeders themselves, the low feeders,  
25 as I mentioned, are stainless, and then there will be

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1 a transition weld from that to carbon steel feeder,  
2 but how sort it is, that still remains to be  
3 determined, and then you have a pooling also from the  
4 header where it is connected on the upper feeders.

5 MR. LEGER: All right. So most of the  
6 rest of the talk deals with fuel channels, and the  
7 fuel channel is designed, of course, to Canadian  
8 standards, but it's designed to meet the intent of  
9 ASME with accommodation for the particular aspects of  
10 pressure tube and the requirement to be able to  
11 refuel.

12 So the zirc-niobium material, of course,  
13 isn't an ASME code material, and the stainless steel  
14 end fitting, which is a modified 403 stainless steel,  
15 Martensitic stainless steel, that is also not ASME,  
16 and there are some other design differences. There  
17 are roll joints as we talked about between the  
18 pressure tube and the end fitting, and we have a  
19 channel closure as a part of the boundary that's  
20 accessed by the fueling machine.

21 So this is sort of an overview of the ACR  
22 channel, and as you can see, we've got two channels  
23 here basically, one that you can see from the outside  
24 and one that's in a cross-sectional view. And I guess  
25 the features that I'd like to point out here is that

1 at the end we have a channel closure that's accessed  
2 by the fueling machine, and then the feeder pipes are  
3 connected to the end fitting here, and then within the  
4 end fitting there's a liner tube that distributes the  
5 flow.

6 So the flow into the channel would come in  
7 through the feeder pipe and be distributed by a liner  
8 tube which would be similar at both ends of the  
9 channel.

10 So here we've got the flow going this way  
11 in this channel and this way in this channel. All the  
12 other feeder pipes are located here between the  
13 adjacent channels. So the feeder pipes pass in the  
14 spaces between the end fittings along the reactor  
15 face.

16 The end fitting here, which goes from here  
17 to here, is this stainless steel single piece forging,  
18 and it's held in location by this position assembly  
19 which is attached to the end shield at the outside of  
20 the end shield. And then there's a rolled joint here  
21 between the stainless steel and the pressure tube. So  
22 this is the pressure tube here in this location here,  
23 and the pressure tube itself is contained within a  
24 calandria tube. Then the calandria tube, as Stephen  
25 was describing, separates the pressure tube from the

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1 cool moderator which is on the outside, the moderator  
2 water.

3 The calandria tube is rolled into the  
4 inner tube sheet here, and the pressure tube is  
5 supported vertically within the calandria tube on  
6 spacers that are spaced along the length of the  
7 channel. So there are nominally four spacers along  
8 the length of the channel that allow the channel to  
9 accommodate axial displacement. Because of thermal  
10 expansion and so on, the channel is fixed at one end,  
11 and during operation when you heat up, it expands and  
12 it moves on the bearings which are within this lattice  
13 tube in the end shield. So the end fittings are  
14 supported on bearings within the end shield, and if  
15 this end is fixed, then the thermal expansion is  
16 accommodated by the bearings on this end and also  
17 during operation, the channel elongates due to the  
18 irradiation that we were talking about before, the  
19 neutron irradiation.

20 DR. ROSEN: Now, before you go on, let's  
21 focus on this rolled joint for a minute.

22 MR. LEGER: I'm going to talk about the  
23 rolled joint later, but we --

24 DR. ROSEN: Oh, okay. Well, I just wanted  
25 to know a little bit dimensionally how long it is.

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1 How long does the roll actually --

2 MR. LEGER: It's about ten centimeters.

3 DR. ROSEN: Really?

4 MR. LEGER: A little bit less than ten  
5 centimeters.

6 DR. ROSEN: It's very long. It's a very  
7 long role compared to the roll of, for instance, a  
8 steam generator.

9 MR. SIEBER: Pretty high pressure.

10 DR. ROSEN: A steam generator tube and a  
11 USBWR rolled into the tube sheet is quite a bit  
12 shorter.

13 MR. LEGER: It's not a normal roll joint.  
14 I'll get into some of that.

15 MR. SIEBER: Before you flip the channel  
16 closure, is that a threaded plug?

17 MR. LEGER: No. The details here are  
18 being looked at in detailed design, but Jullian  
19 Millard can answer more details about the channel  
20 closure.

21 MR. SIEBER: That's subject to the full  
22 RCS pressure, right?

23 MR. LEGER: Yes, that's right, but it's  
24 designed to take it.

25 DR. SHACK: Is it any different than in a

1 CANDU 6?

2 MR. SIEBER: Well, I don't know what that  
3 is.

4 MR. LEGER: Stephen, maybe you would like  
5 that.

6 MR. YU: Stephen Yu here.

7 What we have got is a semi-modified  
8 conditions of a CANDU 6 sealed closed design because  
9 of the end fitting diameter, because they are  
10 different. So dimensionally, it is very different,  
11 but functionally in terms of the sealing mechanism and  
12 the sealing phase and the principles of how it is  
13 sealed by the reactor coolant pressure are the same as  
14 the CANDU 6.

15 DR. FORD: Could I ask a question? The  
16 fact that you've got boiling of the hot end of the  
17 pressure tube, is that a new feature for the ACR 700?

18 MR. LEGER: No, the current CANDU 6 also  
19 has boiling at the end. In fact, it has a higher  
20 level of boiling at the outlet end.

21 DR. FORD: And is there any extent --

22 MR. SIEBER: Well, let's clarify that just  
23 for a second. The statement that was made before was  
24 that you had two percent quality factory boiling  
25 during a main steam line break, which is pretty

1 severe. The steam plug (phonetic) is very high.

2 MR. LEGER: No, no. We have two percent  
3 boiling during normal operations.

4 MR. SIEBER: During normal operation,  
5 okay.

6 MR. LEGER: Up to two percent.

7 MR. SIEBER: Well, that clarifies that for  
8 me.

9 MR. LEGER: Yes.

10 DR. FORD: Well, my next question is  
11 there's not that many CANDU 6s out there. If that's  
12 the first model that had boiling at the hot end of the  
13 pressure tube --

14 MR. LEGER: No, no. Some of the other --  
15 Darlington also has boiling at the outlet end and some  
16 of the Bruce channels have boiling at the outlet end.

17 DR. FORD: There presumably has been  
18 inspection of those.

19 MR. LEGER: Yes.

20 DR. FORD: And do you see any extensive  
21 corrosion?

22 MR. LEGER: We don't see any effect on the  
23 pressure tube or on the feeders basically related to  
24 boiling.

25 DR. FORD: And they are all zirc, two and



1 a half niobium?

2 MR. LEGER: They're all zirc, two and a  
3 half niobium.

4 DR. ROSEN: No deposition of any kind?

5 MR. LEGER: No. There's very, very little  
6 heat transfer at the pressure tube surface. It's not  
7 like fuel.

8 DR. RANSOM: These bearings that you  
9 mentioned for the axial growth, they have seals to  
10 prevent the CO<sub>2</sub> from --

11 MR. LEGER: Well, the bellows here is on  
12 the end, and it seals to the end fitting. It's a  
13 shrink fit and a weld.

14 DR. RANSOM: So the bellows primarily  
15 seals the CO<sub>2</sub> from surroundings?

16 MR. LEGER: Pardon?

17 DR. RANSOM: It primarily seals the CO<sub>2</sub>  
18 from the surroundings.

19 MR. LEGER: That's right. The annulus gas  
20 is a closed system.

21 DR. WALLIS: And as the tube grows, those  
22 bellows expand.

23 MR. LEGER: That's right.

24 DR. WALLIS: But presumably then the tube  
25 must stick out further because I don't see any way of

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1 accommodating the growth of the tube itself.

2 MR. LEGER: That's right.

3 DR. WALLIS: So presumably --

4 MR. LEGER: The end fittings --

5 DR. WALLIS: -- the fueling machine backs  
6 off a bit.

7 MR. LEGER: That's right. The end  
8 fittings move axially outward.

9 DR. WALLIS: The whole thing grows out.

10 DR. SHACK: And the feeder tube bends.

11 MR. LEGER: And the feeder tube bends.

12 DR. WALLIS: That's right. I was going to  
13 ask that, too. Right.

14 And since one is held at a different end,  
15 so --

16 MR. LEGER: No, no, no. At any one time  
17 at one end they're all fixed.

18 DR. WALLIS: They're all fixed at one end.

19 MR. LEGER: So all of the motion is at the  
20 other end of the reactor. And then part way through  
21 life in the current CANDUs you fix the other end and  
22 allow the channel the grow the opposite way.

23 DR. FORD: And so presumably there has  
24 been a fatigue analysis done of that feeder tube to  
25 pressure tube joint because presumably if you're going

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1 to load follow, you're going to have a cyclic stress  
2 on that. No?

3 MR. LEGER: Well, the number of heat-ups  
4 and cool-downs is taken into account in the design,  
5 yes.

6 DR. FORD: From a fatigue perspective.

7 MR. LEGER: From a fatigue perspective.

8 DR. FORD: And what sort of design curve  
9 do you use for stainless steel feeder tube versus  
10 cycles? Do you use an ASME III code?

11 MR. LEGER: Yes, it would be. It would be  
12 done according to ASME III.

13 DR. FORD: Taking into account the latest  
14 information about fatigue of stainless steels in  
15 reducing environments?

16 MR. LEGER: It will be looked at, yes.

17 DR. FORD: Okay.

18 MR. LEGER: All right? Any others?

19 DR. ROSEN: You said you promised me a  
20 discussion of the rolled joint, but I don't see it in  
21 your presentation. Is it in some other place?

22 MR. LEGER: There's a picture of the  
23 rolled joint, and I was going to talk a little bit to  
24 that picture.

25 DR. ROSEN: All right.

1 MR. LEGER: So this is just a summary of  
2 what experience we've had with CANDU. We've had 41  
3 years of experience with pressure tube reactors in the  
4 CANDU community. There's approximately 400 reactor  
5 years of operation of large CANDUs worldwide, starting  
6 sine Pickering II in 1971, and the longest operating  
7 zirc-niobium pressure tubes that are currently in  
8 service have 150,000 hours of operation on them.

9 As we talked before, the pressure tubes  
10 change dimensions over their lifetime, and just to  
11 give you a sense of what these changes are, for ACR,  
12 we're expecting that the maximum diametrical strain  
13 seen in any pressure tube would be four, four and a  
14 half percent diametrical expansion over the 30-year  
15 life.

16 And associated with that, there's an  
17 elongation and a seven percent wall thinning expected  
18 during the 30-year pressure tube life. This  
19 phenomenon is due to the irradiation treatment growth  
20 of the anti-strophic material under the neutron array  
21 fast flux that it sees during operations.

22 DR. WALLIS: Does this change the actual  
23 nature of the material?

24 MR. LEGER: It does have some changes it  
25 affects. It has some changes on the microstructure.

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1 It changes the strength of the material. The strength  
2 actually increases.

3 DR. WALLIS: So there are a lot of atoms  
4 which are knocked around by neutrons and reattached to  
5 things or move around in the lattice.

6 MR. LEGER: They move around in the  
7 lattice. Every atom in the pressure tube gets  
8 displaced on average about once a year. That's the  
9 sort of --

10 DR. WALLIS: Pretty severe bombardment.

11 MR. LEGER: But the microstructure looks  
12 the same even after 20 years of irradiation. It looks  
13 very similar, except it has --

14 PARTICIPANT: It's displaced, but it  
15 doesn't go very far.

16 MR. LEGER: It doesn't go very far. All  
17 of these dimensional changes are accommodated by  
18 design, and we have methods of calculating what the  
19 deformation would be based on the experience that  
20 we've had, and on a large program of research and  
21 development that has been going on for some time.

22 So the experience in the R&D programs  
23 cover the range of ACR conditions that we're going to  
24 be having.

25 The elongation itself is accounted for in

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1 all of the feeder clearances and so on and in the  
2 stresses in the feeders. The impact of the  
3 diametrical expansion for fuel cooling is also  
4 something that is taken into account.

5 DR. FORD: Is there a good database for  
6 radiation hardening of this particular material?

7 MR. LEGER: We have a substantial database  
8 of material removed from CANDU 6 reactors, yes.

9 DR. FORD: I'm just thinking, for  
10 instance, the changes in K1C for stainless steel.

11 MR. LEGER: Yes.

12 DR. FORD: Which is a lot of material out  
13 there, is incredibly scattered as a function of  
14 fluence. Is that the same? Do you have well behaved  
15 relationship between K1C and fluence, for instance?

16 MR. LEGER: We've measured the fracture  
17 toughness of pressure tubes using both small specimens  
18 and burst tests of material removed from pressure  
19 tubes taken out of reactors. So we have a substantial  
20 database. We have tested more than 1,000 small  
21 specimens of different pressure tubes over a number of  
22 years, and we have a significant database of material  
23 characteristics after radiation.

24 DR. FORD: Okay, and there's not a big  
25 scatter. What's the uncertainty of these

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1 calculations?

2 MR. LEGER: Well, there are differences  
3 between different pressure tubes that we're making  
4 progress in identifying the causes of all the  
5 differences, and that was one of the reasons for  
6 changing some of our chemistry specifications for the  
7 material, and now we've got a material that maintains  
8 its fracture toughness much better than some of the  
9 tubes that are currently installed in CANDU reactors.

10 DR. FORD: Okay.

11 MR. LEGER: Just to give you a sense of  
12 how our predictions work, for example, for diametral  
13 strain rates, this is just a plot of predicted strain  
14 rates using our design equation versus measured strain  
15 rates for pressure tubes installed in quite a number  
16 of different reactors, all with slightly different  
17 coolant temperature conditions and neutron fluences.

18 So some of this variability that you see  
19 here is material variability and some is variability  
20 that isn't -- no, I'll just say it's material  
21 variability.

22 So our expectation with regard to despite  
23 these significant strains that we're seeing, we don't  
24 see any issue with pressure tube ductility limits.  
25 The material is deforming under a radiation, and

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1 that's in a condition with very low stress exponent,  
2 that's close to one, and under these conditions, you  
3 expect to get a behavior that's almost super plastic.

4 So we don't see anything in the  
5 microstructures of tubes removed from service that  
6 have significant diametral strains to indicate that  
7 there's any creep ductility limit that's being  
8 approached here.

9 DR. WALLIS: Very high strain. We're  
10 probably indicating such as a clarian tube.

11 MR. LEGER: Pardon?

12 DR. WALLIS: Very high strain. It would  
13 probably bring it up in contact with the clarian tube.

14 MR. LEGER: No, the clearances there are  
15 much greater than four percent.

16 DR. WALLIS: But the failures. Sorry. So  
17 you mean it's to incipient failure. It's not as it  
18 begins to fail you get the very high strain. You mean  
19 it allows a creep strain. Your very high strain  
20 refers to a creep strain rather than a strain when it  
21 begins to burst?

22 MR. LEGER: Yeah. With regard to this, I  
23 was talking about creep strain; that we're not  
24 expecting that creep strain will be an issue with  
25 regard to creep ductility.

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1 PARTICIPANT: Does that strain rate  
2 increase or decrease with time?

3 MR. LEGER: It tends to increase very  
4 slightly with time.

5 DR. RANSOM: So with these time is going  
6 on your plot --

7 MR. LEGER: Sorry. These were just  
8 comparisons of the measured strain rate. Yes, these  
9 are strain rates. Sorry.

10 DR. RANSOM: But they're in a series.

11 MR. LEGER: In some cases the measurements  
12 have been made over time.

13 DR. RANSOM: And so time is going to the  
14 right?

15 MR. LEGER: Sorry, no. In this plot, I  
16 think I'm going to have to perhaps answer that  
17 question --

18 DR. APOSTOLAKIS: Time has nothing to do  
19 with this plot.

20 MR. LEGER: No, these are predicted  
21 strain --

22 DR. APOSTOLAKIS: Pressures measured.

23 MR. LEGER: -- rates versus measured  
24 strain rates.

25 DR. RANSOM: Well, on the same material

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1 then, which is each one of the points --

2 MR. LEGER: No, the strain rate, if you're  
3 at the left on this plot, you're at a very low neutron  
4 fluence. The flux rate would be low, and if you're at  
5 this side, the flux is higher and the strain rate is  
6 higher.

7 DR. RANSOM: Oh, so the flux is varying.

8 MR. LEGER: That's right.

9 DR. APOSTOLAKIS: But the C61a nd so on,  
10 these are different materials?

11 MR. LEGER: They're different tubes.

12 DR. APOSTOLAKIS: They're different tubes.

13 MR. LEGER: They're different tubes, data  
14 from different tubes.

15 DR. APOSTOLAKIS: Because there seems to  
16 be some consistency there. There is no variability is  
17 there?

18 MR. LEGER: Well, single tubes behave,  
19 tend to behave in one way.

20 DR. APOSTOLAKIS: Right.

21 MR. LEGER: I mean, when you go to a  
22 different tube, the material variability makes that  
23 tube creep, for example, a little bit faster or a  
24 little bit slower than some other tube, but the whole  
25 tube would be creeping at a particular rate --

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1 DR. APOSTOLAKIS: Right.

2 MR. LEGER: -- depending on the material,  
3 but different parts of the tube creep at different  
4 rates because the neutron fluxes are different along  
5 the tubes.

6 DR. FORD: In that particular algorithm  
7 presumably the two inputs are stress and temperature,  
8 and those are the only two?

9 MR. LEGER: It's stress and temperature  
10 and neutron fluence, neutron flux.

11 DR. FORD: Flux, not fluence?

12 MR. LEGER: It's neutron flux. It's a  
13 neutron flux term.

14 DR. WALLIS: So this is a plot of material  
15 behavior that doesn't need a log scale in order to put  
16 the points on the piece of paper?

17 (Laughter.)

18 DR. WALLIS: That's an inside joke.

19 MR. LEGER: Let's see. I went through  
20 that.

21 In terms of our experience with pressure  
22 tube integrity, we've had no pressure tube leaks due  
23 to design or material performance since 1986. We did  
24 have some early leaks in zirc-niobium pressure tubes  
25 in the Pickering reactors. This was back in 1974 and

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1 '75 due to delayed hydride cracking near rolled  
2 joints.

3 So the rolled joints had high residual  
4 stresses, and that resulted in a cracking problem.

5 There also was a rupture of a Zircaloy-2  
6 pressure tube in a Pickering reactor that happened at  
7 power, and that was due to contact between the  
8 pressure tube and the surrounding calandria tube that  
9 resulted in hydride blistering and a crack developing  
10 from blisters. And the pressure tube ruptured at  
11 power, but the calandria tube remained intact. The  
12 reactor was shut down safely without any of the safety  
13 systems having to be brought into action.

14 We had one rupture at cold conditions from  
15 a long manufacturing flaw that started at one of these  
16 rolled joints that had high residual stress, but the  
17 issues that led to these early failure have been  
18 solved basically. We've developed low residual stress  
19 joints that eliminate these high residual stresses in  
20 the pressure tubes. We have new channel spacer design  
21 that prevents the spacers from moving and prevents the  
22 pressure tubes from coming into contact with the  
23 surrounding calandria tubes.

24 We've improved our manufacturing  
25 practices, and we have better inspection during

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1 manufacturing to reduce the chance of having a long  
2 manufacturing flaw in a pressure tube.

3 DR. FORD: Now, the thickness of your  
4 tubes have changed for the ACR 700 versus the CANDU 6.

5 MR. LEGER: That's right.

6 DR. FORD: Which all impact onto these  
7 various engineering changes you've made, the creep  
8 rates and touching the calandria tube, the residual  
9 stresses in your rolled joint.

10 MR. LEGER: Yes.

11 DR. FORD: So how certain are you that  
12 you're not going to have a problem with some sort of  
13 probability aspect.

14 MR. LEGER: Well, the changes have been  
15 made in a direction that should improve things, in  
16 fact.

17 DR. FORD: Yes.

18 MR. LEGER: Because the stresses are  
19 reduced. The stresses in the pressure tube are  
20 reduced relative to what they are in the CANDU, for  
21 example. The rolled joints here in the stages of  
22 going through a development process for the rolled  
23 joint because of the different thickness so --

24 DR. FORD: I guess my question is really  
25 you had two failures, Bruce and Pickering due to

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1 failures because of stress or whatever it might be.  
2 We'll come to that in a minute or two. And you said  
3 that you've improved things from that early  
4 experience.

5 MR. LEGER: Yes.

6 DR. FORD: Different material, thicker  
7 material, and it's a qualitative feeling that things  
8 are better?

9 MR. LEGER: No, it's the --

10 DR. FORD: And you're never going to have  
11 another Bruce or Pickering incident?

12 MR. LEGER: Well, we are required to be  
13 certain that we won't have pressure tube/calandria  
14 tube contact, for example. That's one of the  
15 requirements of the standard.

16 DR. FORD: So presumably you've got a  
17 fairly extensive database of all interactions between  
18 DHC and irradiation and temperature and stress and  
19 material.

20 MR. LEGER: We have a large database of --

21 DR. FORD: And those interactions to be  
22 certain that you would never have a contact between  
23 the tube and the calandria?

24 MR. LEGER: Well, the contact between the  
25 tube and the calandria depends on the creep of the

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1 channel and on whether the spacers remain in their  
2 design locations, and so the spacers for ACR will be  
3 not exactly the same spacers as --

4 DR. FORD: I guess why I'm asking the  
5 question, as you know, in this country we have had 40-  
6 odd years of many, many manhours of experience of  
7 saying that austerlic (phonetic) alloys, nickel based  
8 stainless steels will never crack, and yet even now  
9 we're still getting unpleasant surprises.

10 And so when you say that you're certain  
11 that something will not happen, I'm interested to know  
12 why the certainty.

13 MR. LEGER: We think it's a very low  
14 probability.

15 DR. FORD: Okay, okay.

16 DR. ROSEN: So you're taking "certain"  
17 back?

18 DR. FORD: Well, the design is intended to  
19 address all of these issues. The safety analysis  
20 covers the potential that it doesn't.

21 DR. SHACK: You're so certain that you're  
22 going to change them out at 30 years.

23 DR. FORD: I want to know what the  
24 criteria are.

25 MR. LEGER: The 30 years has to do with

1 the limits on, for example, diametral expansion that  
2 you can tolerate.

3 In terms of the cracking mechanism that  
4 we've studied over time, the cracking mechanism by  
5 delayed hydride cracking is something that we have  
6 been studying for quite a long time. We understand it  
7 very well, and we know that cracking won't be possible  
8 at operating temperatures, given that the hydrogen  
9 content of the tube remains below the solubility limit  
10 in the material.

11 And we avoid crack initiation by having  
12 these low residual stress joining techniques and by  
13 preventing debris flaw formation in the system by  
14 keeping it clean.

15 Any cracking that could potentially occur  
16 at low temperature where the solubility of hydrogen is  
17 exceeded, the cracking is avoided by having lower  
18 pressures.

19 In zirc-niobium material, of course,  
20 hydrogen goes into solution. This is just a plot of  
21 the hydrogen concentration on a log scale versus the  
22 one over T because it's a sort of thermally activated  
23 process. So there's a solubility limit. As long as  
24 the hydrogen concentration is below this limit, then  
25 hydrides won't form in the material and you can't have

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1 delayed hydride cracking.

2 So we currently have experience up to  
3 CANDU 6 temperatures. The ACR is slightly higher  
4 temperature. The pressure tubes do pick up hydrogen  
5 through the corrosion reaction that occurs on the  
6 inside surface with the coolant. So a fraction of  
7 this hydrogen generated by the reaction is picked up  
8 by the material.

9 And if you do get into a situation where  
10 hydrides are present, then there is a potential that  
11 there could be a fracture concern.

12 DR. FORD: But your thesis is hydrogen is  
13 necessary, but it is not the only criterion. For  
14 instance, Bruce and Pickering have failed and,  
15 therefore, they --

16 MR. LEGER: Yes, but that's hydrogen.

17 DR. FORD: I'm puzzled then because  
18 what --

19 MR. LEGER: All of the cracks that have  
20 occurred in pressure tubes have been attributed to  
21 delayed hydride cracking.

22 DR. FORD: Okay. So if you don't have  
23 hydrides, then you can't have cracking, and yet  
24 Pickering and Bruce did.

25 MR. LEGER: They didn't crack at reactor

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1 operating temperature. They cracked when the reactors  
2 were shut down due to these high residual stresses in  
3 the rolled joints.

4 DR. FORD: Okay. And we're not going to  
5 have this problem with the ACR 700?

6 MR. LEGER: No, no. The target is to keep  
7 the hydrogen concentration below this solubility limit  
8 in the main body of the pressure tube during reactor  
9 operation.

10 DR. FORD: Okay.

11 DR. WALLIS: How about the water chemistry  
12 side? You control the hydrogen?

13 MR. LEGER: Yes, the water chemistry is  
14 controlled. It has its -- lithium hydroxide is added  
15 to keep the pH up for the carbon steel parts of the  
16 system, and the hydrogen is added at levels that are  
17 in the range of three to ten cc's per kilogram.

18 DR. WALLIS: That's to weed out the oxygen  
19 in the water.

20 MR. LEGER: That's right.

21 DR. WALLIS: And then that hydrogen  
22 doesn't affect the --

23 MR. LEGER: No. The hydrogen doesn't seem  
24 to --

25 DR. WALLIS: It doesn't have an impact.

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1 MR. LEGER: No, it doesn't.

2 DR. FORD: And so just to follow on my  
3 concern, I grant you that under operating temperatures  
4 and operating conditions you don't have a problem, but  
5 during an accident situation where you may lower the  
6 temperature, it's really like a PTS situation for  
7 current pressurized water reactors. You could have a  
8 problem then, couldn't you, with the zircaloy?

9 The temperature goes down, i.e., goes to  
10 the right on that plot --

11 MR. LEGER: Yes.

12 DR. FORD: -- and then you would have a  
13 problem of cracking as happened at Bruce and  
14 Pickering?

15 MR. LEGER: I don't know exactly what  
16 scenario you're thinking about. I mean, if you are  
17 under low temperature conditions where you have high  
18 stresses and you've got a crack that could potentially  
19 grow --

20 DR. FORD: Yes.

21 MR. LEGER: -- then the crack could grow  
22 at a rate that would be determined by the delayed  
23 hydride crack velocity curve, which we have in detail.

24 DR. FORD: I guess my concern is on that  
25 plot you're saying anything below that thick line, no

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1 problem at all with DHC, and yet we did have cracking  
2 at two --

3 MR. LEGER: At the operating temperature.

4 DR. FORD: That's my point.

5 MR. LEGER: Yes.

6 DR. FORD: And you explain away the Bruce  
7 and Pickering experience of cracking as happened at  
8 low temperature. Now I'm asking the question, well,  
9 that could happen with the ACR 700, could it not?

10 MR. LEGER: Well, at low temperature, as  
11 I was indicating before, the reason why it happened at  
12 low temperature was because there were still some very  
13 high residual stresses present in those tubes, and so  
14 there was a driving force at low temperature. In  
15 ACR --

16 DR. FORD: You won't have that.

17 MR. LEGER: -- we won't have that.

18 DR. FORD: Okay.

19 MR. LEGER: Again, in terms of how much  
20 hydrogen gets picked up, well, in CANDU reactors, the  
21 corrosion of pressure tubes so far after 20 years of  
22 operation, we have oxide thicknesses on the inside of  
23 the pressure tube that are in the range of 20 to 30  
24 microns, and the maximum hydrogen that's picked up,  
25 although it's picked up as deuterium in our current

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1 CANDU 6 reactors, it's equivalent to about 20 parts  
2 per million of hydrogen after 20 years of operation,  
3 except near the rolled joints where there's higher  
4 hydrogen pickups.

5 So the rolled joints, the areas of the  
6 rolled joints do pick up some higher levels of  
7 hydrogen.

8 MR. SIEBER: Why is that?

9 MR. LEGER: Well, we think it's a galvanic  
10 interaction between the pressure tube and the end  
11 fitting that's causing the pickup in the pressure  
12 tube.

13 MR. SIEBER: Oh, okay. Could you describe  
14 what this low stress rolling technique is?

15 MR. LEGER: Well, the low stress rolling  
16 technique is basically a technique that in the current  
17 CANDUs -- and as I said, we are going through a  
18 development program for the ACR to demonstrate that  
19 we'll be able to achieve the same good flow stress  
20 rolled joint which is different because of the  
21 differences in the wall thickness and so on.

22 But in the current CANDUs, the rolled  
23 joints are what are called a zero clearance rolled  
24 joint, and in order to make the rolled joint, the end  
25 fitting is heated up, and the pressure tube is

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1 inserted. It's actually an interference fit within  
2 the rolled joint, and then the rolling takes place.

3 And that leaves the material in the  
4 pressure tube just on the inside of the rolled joint  
5 where it's not supported in a compressive stress  
6 situation rather than a tensile stress.

7 MR. SIEBER: Thank you.

8 MR. LEGER: So we have models of corrosion  
9 and hydrogen pickup that are based on experimental  
10 programs, and these models are compared with the  
11 observations that we have from surveillance from  
12 reactor.

13 We have models for both how hydrogen gets  
14 picked up in the rolled joints and in the main body of  
15 the tube. This is a plot of how hydrogen behaves in  
16 CANDU 6 reactors at the five meter location, which is  
17 five meters from the inlet end. It's the position  
18 that has the highest pickup rate in the CANDU 6  
19 channel.

20 This is deuterium concentration. So you  
21 have to divide these numbers by two to get hydrogen  
22 basically, and this is time in hot years. So ten hot  
23 years is 87,600 hot hours of operation, and so the  
24 model that was derived from experiments and from lab  
25 experiments is the solid middle line, and the

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1 measurements from reactor are shown here.

2 So there's some variability again, which  
3 is material variability primarily, and some reactor-to  
4 reactor variability as well.

5 But for our predictions for ACR, we use an  
6 upper bound of these curves. So getting to pressure  
7 tube leak before break, leak before break is seen as  
8 a defense in depth for normal operation. The annulus  
9 gas system is used as a leak detection system. So the  
10 gas is circulated through the gas annuli between the  
11 pressure tubes, and if there is a leak, it picks it  
12 up. The gas system is monitored continuously for  
13 moisture content.

14 In ACR the response time of this system is  
15 going to be significantly improved relative to what is  
16 currently in place in the other reactors that we have.

17 We know that fracture toughness and crack  
18 growth rates are, pressure tube material, and leak  
19 before break basically means that you have to be able  
20 to demonstrate that using your upper bound crack  
21 growth rates and your lower bound fracture toughness  
22 values, that you have a database for it that you can  
23 show that if you do get a leak, that you will have  
24 time to be able to detect that leak, have the operator  
25 react to that leak, shut down the reactor, and

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1 maintain the pressure boundary in a satisfactory  
2 condition without the crack becoming unstable.

3 So leak before break for a reactor is  
4 demonstrated by a sequence of events analysis. So you  
5 postulate that you have a crack, that it's growing,  
6 that it starts leaking. We have models for what the  
7 leak rate will be and what the response of the system  
8 will be in terms of detection, operator action, and so  
9 on, and we know what the crack growth rates are. We  
10 know what the minimum instability crack length is, and  
11 so we can demonstrate that we have leak before break  
12 for pressure tube in the reactor.

13 DR. FORD: Obviously the veracity, if you  
14 like, or the supporting documentation to come up with  
15 that end conclusion, you've got to go into the whole  
16 question of the scatter of the pressure mechanics data  
17 and the crack growth rate data.

18 MR. LEGER: That's right.

19 DR. FORD: Plus whether it's an axial  
20 versus circumferential crack. Has all of that data  
21 been made available to the NRC so that they can come  
22 to their own independent view on that?

23 MR. LEGER: Some of the data has been made  
24 available, but I don't think that -- I'm not sure  
25 whether we've given all of the data. We made a



1 presentation in December of 2002 where we showed all  
2 of the data, but in terms of what's actually been  
3 transmitted, we have a lot of significant quantity of  
4 the data in this document on the technology of fuel  
5 channels that was given to the U.S. NRC.

6 But in terms of whether -- I don't think  
7 even in here it includes all of the data out to the  
8 highest fluences that we have because this is a public  
9 document.

10 DR. SHACK: In addition to the leak before  
11 break, do you do a volumetric inspection, ultrasonic  
12 or eddy current under pressure tubes?

13 MR. LEGER: Well, they're inspected during  
14 manufacture.

15 DR. SHACK: Right, but I mean in service.

16 MR. LEGER: In service we have a program  
17 of in-service inspection, but it inspects the fraction  
18 of the tubes in general, the small fraction of the  
19 tubes. So the --

20 DR. SHACK: And small fraction is 20  
21 percent?

22 MR. LEGER: In current reactors it's less  
23 than 20 percent. I think the current standard is  
24 being rewritten to increase the amount of inspection  
25 that's done, but the amount of inspection that's

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1 required is quite small. It's a small number of  
2 tubes, and basically --

3 DR. SHACK: Is this an eddy current probe  
4 on the surface?

5 MR. LEGER: It's basically an inspection  
6 to detect a generic degradation problem that could  
7 affect a large number of channels rather than a  
8 specific channel inspection because all of the  
9 channels are basically operating in the same  
10 condition.

11 All right. The fuel channel standards,  
12 the pressure tube is designed to this CSA Canadian  
13 standard, CSA N-285.2. So the tubes meet a material  
14 standard which is an N-286.6, and additional ACL  
15 technical specifications. So the standard is a  
16 general standard. ACL has some additional  
17 requirements on the pressure tube material that are in  
18 our technical standards.

19 Zirc-niobium material is an ASTM material.  
20 It's in the ASTM standard B-353 as UNSR-60901  
21 material, and basically for these standards we've used  
22 an ASME type of criteria to establish the allowable  
23 design stress levels. So the allowable design stress  
24 level is determined by the minimum strength of the  
25 material, either the UTS or the -- it's actually the

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1 UTS. It's one-third of the UTS that's used as the  
2 design stress level, stress allowable level.

3 The tubes that we produce basically are  
4 consistent, high quality product. The current tubes  
5 that are being produced have improved properties  
6 relative to earlier production and these improved  
7 properties have been established through the research  
8 programs that have been done over the years. One of  
9 the major factors, I think, that I mentioned before  
10 was this improved fracture toughness after  
11 irradiation.

12 That resulted from an R&D program that  
13 identified chlorine as being a bad thing to have in  
14 pressure tube material. It really had an impact on  
15 how the fracture toughness decreased effluence, but  
16 now we have manufacturing methods that reduce the  
17 chlorine content so that we get very high fracture  
18 toughness.

19 DR. ROSEN: Who actually makes these  
20 tubes?

21 MR. LEGER: Pardon?

22 DR. ROSEN: Who actually makes them?

23 MR. LEGER: The tubes are made -- in  
24 Canada the tubes are manufactured by NUTECH, which  
25 used to be Chase Nuclear in the States, but the

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1 material itself, we've had two sources of material,  
2 well, actually more than two sources, but two sources  
3 of material over time. The material is supplied by Wa  
4 Chang (phonetic) in Albany, Oregon, or for the Qinshan  
5 project the pressure tubes were -- the material was  
6 supplied by a Chepetski (phonetic) plant in Russia.

7 The tubes are actually manufactured in  
8 Arnprior, Ontario, by NUTECH Precision Metals.

9 Just in terms of the rolled joints, the  
10 rolled joints also meet a Canadian standard, and this  
11 standard is made to reflect the ASME code requirements  
12 of design by analysis. So we're looking at being able  
13 to show that the stresses in the joint are acceptable  
14 and so on.

15 The resulting joint is this strong joint.  
16 It has to be able to -- the code requires it to be  
17 able to withstand three times the design condition  
18 axial load, including pressure. The qualification  
19 program is carried out with production grade joints,  
20 and each reactor joint when the reactor is actually  
21 assembled, each joint is checked to make sure that the  
22 wall thickness reduction that has been achieved by the  
23 rolling is within the range of acceptable wall  
24 thickness reductions for the pressure tube rolled  
25 joint and the leak rate of the joint is checked using

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1 a helium leak detection system.

2 DR. ROSEN: This is field operations,  
3 right?

4 MR. LEGER: It's a field operation.  
5 That's right, although in ACR the reactor, including  
6 the pressure tubes -- maybe, Stephen, you could say  
7 something about that.

8 MR. SIEBER: It's a factory assembly.

9 MR. LEGER: It will be a module.

10 MR. YU: Even on recent reactor  
11 construction that we have, a facility for the  
12 installation the rolled joint, so it's a clean  
13 environment for doing that. I think in the module  
14 concept we would do very similar, whether it is in the  
15 location off site or on site. They would still be the  
16 same clean environment for the rolled joint  
17 installation.

18 DR. ROSEN: Well, the difference is  
19 whether or not there are transportation stresses,  
20 whether the rolled joint is made in the place where  
21 it's going to operate or whether it's made remotely  
22 and then shipped. So that's all I was asking. And  
23 you're saying it could be made remotely and shipped as  
24 part of a module.

25 MR. YU: That's correct.

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1 DR. RANSOM: After 30 years you change out  
2 this tube, right?

3 MR. LEGER: that's right.

4 DR. RANSOM: How is that taken out? Just  
5 cut them and then --

6 MR. LEGER: The tubes would be cut and  
7 removed, yes.

8 DR. RANSOM: And the bells are rewelded  
9 when you put it back in, I guess.

10 MR. LEGER: Well, the process for ACR,  
11 does anyone have the details of the process that will  
12 be used for ACR? I don't.

13 MR. YU: Well, in general, one of the  
14 emptying would be removed, and then, you know, after  
15 the rolled joint is cut, the next picture will show  
16 that we have two sets of rolled joints in there,  
17 grooves ready so that after the two ends are cut, then  
18 the pressure tube can be removed, and they are removed  
19 and then collapsed to reduce the volume of waste, and  
20 then the new pressure tube we put in with the end  
21 fitting on the end where the end fitting was removed.

22 So it's just two joints in the pressure  
23 tube that the pressure tube is new material. We reuse  
24 the end fittings.

25 DR. RANSOM: I guess the rolling process

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1 is rolled from the interior.

2 MR. YU: That's right.

3 DR. RANSOM: And expanded into the --

4 MR. YU: That's correct. I think the  
5 rolling is taking place from within.

6 DR. ROSEN: And now here's the picture you  
7 promised me, and you're going to take me through that  
8 slowly.

9 MR. LEGER: Yes. Here's the picture. So  
10 these are the --

11 DR. ROSEN: Including the heat treatment  
12 and all the rest.

13 MR. LEGER: Pardon?

14 DR. ROSEN: Including the heat treating.

15 MR. LEGER: The heat treating?

16 DR. ROSEN: Didn't you say it was heated  
17 up?

18 MR. LEGER: Well, the end fitting, to make  
19 the current zero clearance rolled joints, the end  
20 fitting is heated up for CANDU 6 reactor. The end  
21 fitting is heated up, and then the pressure tube is  
22 inserted, and then it is cooled down, and then the  
23 rolling takes place, the mechanical rolling. The  
24 rollers are inserted, and a tapered plug is pushed in  
25 as the rolls take place. So it's a propulsive rolling

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1 technique, and the tube is rolled and the pressure  
2 tube actually gets extruded into grooves in the end  
3 fitting, and it's these grooves in the end fitting and  
4 the pressure tube extrusion into these grooves that  
5 gives the rolled joint its very good strength  
6 characteristics. So that's where the strength comes  
7 from.

8 And this is an ACR designed rolled joint.  
9 So as Stephen mentioned, this set of groovers would be  
10 used for the initial pressure tube that was put in, and  
11 then the pressure tube would be cut here, and this  
12 pressure tube would be removed. The original pressure  
13 tube would be removed, and the new pressure tube would  
14 be inserted and rolled into these groups. That's the  
15 intent.

16 MR. SIEBER: You have to move that end  
17 fitting out of the way to get the tube in though.  
18 Does that mean --

19 MR. LEGER: One end fitting would be left.

20 MR. SIEBER: You'd have to cut the feeder  
21 pipe.

22 DR. ROSEN: Now, you're very careful to  
23 say that for CANDU the end fitting is heated up. Does  
24 the ACR also heat up the end fitting?

25 MR. LEGER: Well, we're in the midst of



1 going through a development program for the rolled  
2 joint to be able to demonstrate that we've got all the  
3 characteristics that are required.

4 DR. ROSEN: What does that mean? What did  
5 you just say? Did you just say you don't know yet?

6 MR. LEGER: Well, we haven't -- the  
7 detailed rolled joint, the demonstration that we've  
8 got that the rolled joint has been developed to a  
9 satisfactory level, it's a development program for the  
10 ACR rolled joint.

11 DR. ROSEN: Okay. We're all speaking the  
12 English language now, and what you're saying --

13 MR. LEGER: What i'm saying is that we  
14 have a CANDU 6 rolled joint, that the ACR geometry is  
15 going to be different because the pressure tube is  
16 thicker and because some of the clearances and so on  
17 are different, and so we have to go through a  
18 development program for the ACR rolled joint which is  
19 not yet completed.

20 DR. ROSEN: Do you envision that it will  
21 be like the CANDU?

22 MR. LEGER: Yes, it will be similar, but  
23 it's not going to be identical. Does that -- maybe  
24 Jullian. Can you elaborate on that at all?

25 MR. MILLARD: We've actually got quite an

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1 extensive program going on, including using -- sorry.  
2 I'll go near the microphone.

3 We've got quite an extensive program going  
4 on using a combination of computer based tools and  
5 static testing where we use a program LS Dinez  
6 (phonetic) and Design-aid, which we took out of the  
7 automotive industry. It's used for crash tests, and  
8 we've got a series of tests going on looking at  
9 different variations of groove geometry and clearances  
10 and fitting thicknesses and fitting shrink.

11 If you look on the outside of the end  
12 fitting you'll see that we've got a shrunk reinforcing  
13 ring there.

14 DR. WALLIS: Yeah, I was going to ask  
15 about all of these other colors you've got here.

16 MR. LEGER: Well, these are the bearings  
17 in the lattice tube. This is the lattice tube, which  
18 is not part of the fuel channel. This is the bearing,  
19 and this is the --

20 DR. WALLIS: It's the reinforcement?

21 MR. LEGER: This green part is the  
22 stainless steel 403 forging, and this is the pressure  
23 tube.

24 DR. WALLIS: That yellow thing is a  
25 reinforcement?

1 MR. LEGER: The yellow thing is a  
2 reinforcement.

3 MR. MILLARD: Yeah, it's an inconel  
4 reinforcement that we would like to find a way of  
5 designing out, but just now we've got it in there.

6 CHAIRMAN KRESS: That's so you don't  
7 deflect that part when you do the pressure tube  
8 rolling.

9 MR. MILLARD: Yes. Basically it gives  
10 us --

11 CHAIRMAN KRESS: It keeps it in place.

12 MR. MILLARD: It gives us an interference  
13 fit and alters the stress in site.

14 DR. ROSEN: Well, before you get this  
15 certified we'll have a chance to see hat you're really  
16 going to do here.

17 MR. LEGER: That's right.

18 DR. ROSEN: This is a design detail of  
19 crucial importance.

20 MR. LEGER: That's right, but the intent  
21 is to make a rolled joint that meets our CSA standard  
22 that has these characteristics of high pull-out  
23 strength and no residual stress in the pressure tube  
24 and so on.

25 DR. ROSEN: And in the broad outline it

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1 will involve an end fitting that's heated up and then  
2 an inconel -- I mean a zirc-niobium tube that's  
3 extruded into that heated up end fitting, which then  
4 is allowed to cool. Am I correct?

5 MR. LEGER: No, the sequence is different.  
6 The rolling for the current CANDUs, the rolling takes  
7 place after the whole thing has been cooled. All  
8 right?

9 DR. ROSEN: Okay, and what you're saying  
10 for ACR, the rolling will place hot.

11 CHAIRMAN KRESS: No, he says he doesn't  
12 know yet. Probably cold.

13 DR. ROSEN: I give up. I don't know what  
14 you're going to do.

15 MR. SIEBER: It's the same

16 CHAIRMAN KRESS: It's the same.

17 MR. MILLARD: Basically we've got a heat  
18 shrink of the yellow sleeve, which is actually inconel  
19 just now. So we heat shrink on that the whole end  
20 fitting, push it over the end of the pressure tube,  
21 allow it to cool slightly so that the operators can  
22 get clear without burning their fingers, and then we  
23 put in the rolling tools and expand out, and we  
24 measure out our expansion as we go, and then we  
25 measure the leak rate around it to make sure that our

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1 deformation is okay and our leak rate is okay, and we  
2 do qualification where we do example rolls, where we  
3 cut apart and do pull tests on to prove the process in  
4 general.

5 So we prove the process off line and then  
6 monitor key parameters in that process during  
7 installation in the reactor.

8 DR. FORD: And one of the acceptance  
9 criteria will be that the residual stress for this new  
10 design, whatever it is going to be, is not going to be  
11 sufficient. They're going to push it over the  
12 boundary for delayed hydride cracking.

13 MR. LEGER: That's right.

14 DR. ROSEN: And this may or may not be  
15 done in the field.

16 MR. SIEBER: It's going to not be done in  
17 the field, except for the replacement.

18 CHAIRMAN KRESS: Except for 30 years, 30-  
19 year replacement.

20 DR. ROSEN: Initially it may or may not be  
21 done in the field; is that correct? Because I asked  
22 the question and then I got the answer, "Well, it's a  
23 module that could be fabricated off site."

24 MR. MILLARD: When we do that the first  
25 time in the field, it's done in controlled environment

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1 where quite often they build a tent around so they can  
2 control the environment, but it's still field work  
3 really.

4 MR. SIEBER: Now, the coefficients for  
5 thermal expansion for the two tube materials is such  
6 that when you heat the plant up the joint gets  
7 tighter, right?

8 MR. LEGER: The expansion coefficients are  
9 different.

10 MR. SIEBER: Yes, they have to be.

11 MR. LEGER: But the actual expansion  
12 coefficient for the pressure tube is slightly less  
13 than the end fitting, but the joints do remain tight.

14 DR. ROSEN: So it relaxes a little.

15 MR. LEGER: It relaxes a little. The  
16 interspatial stress would go down, although I'm not  
17 sure with the inconel.

18 MR. SIEBER: So when you test the strength  
19 of the joint, do you test it hot or cold?

20 MR. MILLARD: Test it hot, yeah. You test  
21 leak rate hot and below strength hot.

22 MR. SIEBER: Right.

23 MR. LEGER: So the end fitting I think  
24 we've gone through some of that before. It's a single  
25 forging. It's high strength. It has good fracture

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1 toughness, and we've not identified any issues with  
2 it.

3 In terms of the channel closure, channel  
4 closures are these removable components that allow us  
5 to do the on power fueling. The actual closures  
6 themselves are designed to satisfy ASME Class I design  
7 rules, but they do satisfy the requirements of the  
8 Canadian standard in 285.2.

9 DR. WALLIS: How do they attach?

10 MR. LEGER: Pardon?

11 DR. WALLIS: How do they attach?

12 MR. LEGER: Jullian has it.

13 MR. MILLARD: It's Jullian Millard again.

14 Our attachment of channel closures is by  
15 a series of jaws which go out into the end fitting.  
16 Some of our reactors use a breach log for CANDU 6,  
17 Pickering, and ECR will use this jaw construction.

18 CHAIRMAN KRESS: We'll get into the  
19 details of that later.

20 MR. MILLARD: I think I left my  
21 presentation at too a high a level. So I don't think  
22 I showed a slide of that.

23 CHAIRMAN KRESS: Okay.

24 MR. MILLARD: It can be supplied at a  
25 subsequent date.

1                   CHAIRMAN KRESS: We can put this off until  
2 later to find out about that.

3                   DR. WALLIS: It's just that all of these  
4 places where you might lose the pressure boundary I  
5 think need to be understood.

6                   MR. SIEBER: That one is a key one.

7                   MR. LEGER: The requirements of the code,  
8 of the Canadian code, require that the closure has to  
9 be locked in place to prevent it from being  
10 inadvertently removed, and the closures have to be  
11 leak tested each time they're installed during  
12 operation, like when you do a fueling operation, you  
13 have to leak test the closure before the fueling  
14 machine is removed from the channel.

15                   CHAIRMAN KRESS: Are these sealed by O  
16 rings?

17                   MR. LEGER: Pardon?

18                   CHAIRMAN KRESS: Are these metal O ring  
19 seals?

20                   MR. LEGER: It's a metal-to-metal seal,  
21 yes. The --

22                   DR. ROSEN: So you're proving before you  
23 back away from the face --

24                   MR. LEGER: Yes.

25                   DR. ROSEN: -- that even when you back



1 away it's already sealed.

2 MR. LEGER: That's right.

3 DR. ROSEN: And while you're sealed hooked  
4 to it --

5 MR. LEGER: While the fueling machine is  
6 still hooked to the channel, hooked on the channel,  
7 locked on the channel, a pressure test is done to --

8 DR. ROSEN: You basically depressurize a  
9 space.

10 MR. LEGER: That's right.

11 DR. ROSEN: And check to make sure there's  
12 no leakage into that space.

13 MR. LEGER: That's right.

14 DR. ROSEN: And that the pressure is not  
15 rising in that space.

16 MR. LEGER: That's right.

17 DR. ROSEN: And then when you're convinced  
18 that you've made a good seal --

19 MR. LEGER: Then you can remove the fuel  
20 test. And there are interlocks in place. The code  
21 requires that there are interlocks in place to prevent  
22 the fueling machine from disengaging before the  
23 closure is in place.

24 MR. SIEBER: I take it there's no flow and  
25 no pressure while the actual refueling is taking

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1 place? Has to be or the fuel element would have --

2 MR. LEGER: May Jullian can answer that.  
3 I know in the current fueling machines there is flow,  
4 a small amount of flow injection into the channel  
5 during refueling.

6 MR. SIEBER: I would think that you would  
7 need normal flow.

8 MR. LEGER: Well, no, the whole channel is  
9 undergoing normal flow.

10 MR. SIEBER: Right, okay.

11 MR. LEGER: But in addition to that, the  
12 fueling machines inject a small amount of fluid into  
13 the channel at the same time.

14 MR. SIEBER: Right. That's good enough  
15 for an answer.

16 DR. ROSEN: Now, that additional flow is  
17 process system flow, call it, that actually comes from  
18 an external system; is that correct? And comes  
19 through flexible hoses and somehow is injected into  
20 the channel. Am I correct about all of that?

21 MR. LEGER: That's right, yes.

22 DR. ROSEN: So that those hoses are  
23 actually part of the reactor system, the pressure  
24 boundary during this operation.

25 MR. SIEBER: There's a check valve in

1 there.

2 DR. ROSEN: Is that right?

3 MR. LEGER: That's right, yes.

4 DR. ROSEN: And so those hoses are  
5 designed to ASME Section 3, Class 1?

6 MR. LEGER: Those hoses are designed to  
7 the Canadian standards, CSA and 285.2, and there  
8 are --

9 DR. ROSEN: Because I never heard that  
10 there was a --

11 MR. LEGER: -- requirements; there are --

12 DR. ROSEN: -- set in that Section 3,  
13 Class 1.

14 MR. LEGER: There are requirements on the  
15 hoses as well. Jullian knows more about that than I  
16 do.

17 MR. MILLARD: Basically, the injection  
18 flow is -- Jullian Millard from ACR again.

19 We have got isolation valves and check  
20 valves on the heads, which allowed us to have a good  
21 isolation boundary. So we try and have our hoses  
22 below ASME Section 1 because it's very expensive to  
23 have equivalent of ASME Section 2 hoses and ASME just  
24 now does not cover flexible hoses, which is why we  
25 have additional requirements in our CSA code both on

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1 manufacturing checks and on calculation of service  
2 live.

3 DR. ROSEN: So how much flow is going  
4 through these hoses and check valves? Are we talking  
5 about gallons per minute or --

6 MR. MILLARD: It's normally about 20  
7 gallons per minute that we're putting into the end of  
8 the channel compared to I was thinking metric; is it  
9 25 kilograms a second of flow going down the channel?  
10 So it's a relatively small percentage. It's basically  
11 a flush and flow that we're putting in to make sure we  
12 don't get fuel channel fluid coming into the fueling  
13 machine head even though the fueling machine head is  
14 using process fluid from the pressure and inventory  
15 control system of the new transport system. We try  
16 and run the fueling machine heads cold.

17 DR. ROSEN: And you say there were check  
18 valves. If one of these hoses failed --

19 MR. MILLARD: Yeah.

20 DR. ROSEN: -- you're relying on the check  
21 valve, right?

22 MR. LEGER: We've got isolation valves and  
23 check valves.

24 DR. ROSEN: But the isolation valves are  
25 automatic isolation? I mean, they would sense that

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1 the delta P or how does this work?

2 MR. MILLARD: Just now we've got flow  
3 fuses which are flow based check valves that come in,  
4 and we've also got isolation valves under operator  
5 control.

6 DR. ROSEN: Manual?

7 MR. MILLARD: Manual control, and then  
8 we've got flow measurement so the operators can see  
9 it. They would also see the spray of water coming out  
10 on the vault cameras, but the flow rates are  
11 relatively small, and because that fluid is not coming  
12 out of the channel, it's fluid to do with the fueling  
13 machine system

14 DR. ROSEN: Has that ever happened in  
15 existing machines where you had a failure of a hose?

16 MR. MILLARD: I gather many, many years  
17 ago they did have a failure of a hose, and since then  
18 more stringent quality control was put on the hoses  
19 and also better calculation of service life from the  
20 radiation --

21 CHAIRMAN KRESS: I think I'm going to have  
22 to move this on a little bit. We're getting way  
23 behind.

24 MR. LEGER: I think that was pretty much  
25 it.

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1 CHAIRMAN KRESS: At this time before they  
2 close the cafeteria, I propose we shorten our lunch  
3 period a little to catch up if you guys don't mine,  
4 and I suggest we try to be back here at one.

5 PARTICIPANT: At one?

6 CHAIRMAN KRESS: Well, I'll tell you what.  
7 I'll give you till 1:15. That will put us 15 minutes  
8 behind. So 1:15 we'll recess.

9 (Whereupon, at 12:34 p.m., the meeting was  
10 recessed for lunch, to reconvene at 1:15 p.m., the  
11 same day.)

AFTERNOON SESSION

(1:18 p.m.)

1  
2  
3 CHAIRMAN KRESS: At this time we're going  
4 to change the order of presentations a little bit and  
5 instead of computer codes and validation, we're going  
6 to hear on-power fueling.

7 So you know where to turn to in the  
8 slides.

9 MR. MILLARD: Good afternoon. I'm Jullian  
10 Millard from the Reactor Fuel Handling Branch in ACL.

11 I'm going to give you a quick overview on  
12 on-power fueling. Obviously it's a fairly big  
13 subject. Apart from presentations we've handed over,  
14 we've given a fairly large document giving a lot of  
15 the background data on the technology basis and the  
16 safety background to off-power fueling.

17 And there are a number of meetings coming  
18 up where we're handing over other detailed information  
19 to NRC staff on this.

20 Basically I'm going to discuss the  
21 advantages of on-power refueling on the CANDU reactor  
22 design and how the equipment is used. Basically we do  
23 it to keep the core reactivity low and give us a lot  
24 more flexibility in station outages. So basically  
25 outages don't need to be at a fixed time. They can be

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1 taken at basically a time that the market wants, which  
2 operators prefer a lot.

3 We have been safely and successfully doing  
4 on-power fueling for many decades now in 45 reactors,  
5 and the ACR design is an evolutionary design building  
6 on the best features of our past designs.

7 Basically this is an overview of the  
8 reactor building. This is the fueling machine bridge  
9 down here, and this is the reactor face with our  
10 forest of feeders as you called it down in here in the  
11 red headers, and this is actually SDS-2 here, shutdown  
12 system 2 coming at the site, and SDS-1 is in the deck  
13 on the top here, just to give you an idea of scale.

14 Our ACR-700 reactor, as Stephen says, it's  
15 evolutionary, and we use the small stuff constantly  
16 over the year instead of a larger complement for a  
17 refueling outage.

18 The plan here in the same building, that  
19 last section was a section from this site. So this is  
20 just show the air lock site, which is the main  
21 maintenance air lock site of the building where we've  
22 got our fuel bays for fuel reception and our what we  
23 call maintenance locks, but they're really locks into  
24 which we move the fueling machines for transfer onto  
25 spent and refuel ports.

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1 In the center we've got our coolant supply  
2 for normal operation for the fueling machine.

3 In terms of our fueling scheme, basically  
4 fueling is used as the high level method of keeping  
5 core reactivity at about four and a half milli-K,  
6 which works out at 5.6 bundles per full power day for  
7 daily refueling. Of course, we don't actually do  
8 daily refueling normally. Most of our reactors work  
9 on four days of fueling and three days for maintenance  
10 and other activities, maintenance activities, et  
11 cetera, Christmas holidays where they fuel ahead using  
12 our zone controls to give them a bit of buffer to  
13 allow the fueling staff to have some time off,  
14 holidays.

15 CHAIRMAN KRESS: Does your refueling  
16 machine have to have a flexible hose connected to it  
17 from the cooling line?

18 MR. MILLARD: Yes. I'll show you those in  
19 subsequent pictures.

20 Each two bundle shift replacement gives us  
21 about .2 milli-K of increase in reactivity in the  
22 channel, and our physics staff select the channel  
23 based on the overall core balance where they're taking  
24 about 20 months for fuel to pass through.

25 And it also allows us to take out

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1 defective fuel promptly. As soon as we get any  
2 detection through the heat transport system that we  
3 have defect gases in there, we can go in and home in  
4 on the channel and home in on the bundles and pull  
5 them out.

6 DR. ROSEN: What can you say about fuel  
7 experience? Has there been a lot of fuel, one  
8 percent, tenth of one percent, defective fuel or --

9 MR. MILLARD: I should probably refer that  
10 to Peter Boczar. My memory is at .1 percent fuel  
11 bundles, and it's typically one element for each of  
12 those bundles.

13 DR. ROSEN: A tenth of one percent  
14 typically. Is that what you said?

15 MR. MILLARD: A tenth of one percent, and  
16 that typically relates to manufacturing defects.

17 DR. WALLIS: How long before you reach a  
18 steady state? There must be a starting transient with  
19 this fuel.

20 MR. MILLARD: I should refer that to the  
21 other Peter Chan here.

22 MR. CHAN: I'm Peter Chan from physics.

23 It will take approximately a year for us  
24 to discharge all of the bundles in the first start-up  
25 core.

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1 DR. WALLIS: It's a year, but the typical  
2 fuel residence is 20 months. So you get some unburned  
3 fuel. You're just --

4 MR. CHAN: It's 600 days is the typical  
5 drill time, residence time in the reactor.

6 DR. WALLIS: But you're refueling day by  
7 day, whereas this initial batch really gets old  
8 together.

9 MR. CHAN: The initial batch has lower  
10 enrichment. It will stay in the reactor a lot less  
11 time than the normal fuel.

12 DR. WALLIS: I see. Okay.

13 MR. SIEBER: How many bundles are resident  
14 in a reactor typically?

15 MR. CHAN: Pardon me?

16 MR. SIEBER: How many bundles are resident  
17 in the reactor typically?

18 MR. CHAN: Oh, right now we have 284  
19 channels. Each channel has 12 bundles.

20 MR. SIEBER: Times 12.

21 MR. CHAN: Yeah.

22 MR. SIEBER: Okay. A lot of them.

23 MR. MILLARD: As I said, we have got names  
24 which give us control of spatial reactivity across the  
25 reactor and also give us some method for building

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1 these nice windows for all of these fuel handling  
2 stuff. You can tell it's fuel handling and not  
3 physics, and we've got our full control absorbers for  
4 para-setbacks (phonetic).

5 So basically this picture you've seen  
6 before. You've got the end fitting with its channel  
7 closure. There's a shield plug in here, which is  
8 actually more of a fuel support than a shield plug  
9 because we don't rely on the shielding characteristics  
10 of it, but it does provide some small shielding during  
11 shutdowns, and our reactivity mechanisms which were  
12 totally separate.

13 There's an absorber guide on the outside  
14 of each reactivity mechanism. So basically should  
15 anything happen on the calandria tubes moving, the  
16 calandria tubes would move into the guide. They  
17 wouldn't move on to actually stopping the absorber in  
18 its operation.

19 But I've never seen instances of the  
20 calandria tubes moving to that degree.

21 DR. WALLIS: Do these tubes all stick out?  
22 Are they supported at the ends in some way? Are they  
23 just sticking out like that?

24 MR. MILLARD: They're literally just  
25 sticking out like that. The picture I'll show you

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1 later because the insulation cabinet comes on at this  
2 level here, you only actually see a small stub sitting  
3 out beyond the --

4 DR. ROSEN: But they're cantilevered.  
5 There's no support, right?

6 MR. MILLARD: It's cantilevered. We take  
7 the official support to be coming from here. Even  
8 though there is some loading and support coming  
9 through the heater, everything is designed to be taken  
10 at the root of the fuel channel through the bearings  
11 here and for axial movement on this restraint. So  
12 we've got a pair of bearings which are sliding  
13 bearings to allow our axial -- and then the restraints  
14 in there.

15 DR. ROSEN: Do you ever measure the  
16 vibration at the end of that to see if you had any  
17 displacement?

18 DR. RANSOM: We expect the ends of the  
19 fuel channels to deflect. There is no actual  
20 vibration that we see. I know we've done some  
21 measurement of heat transport system vibration, but we  
22 don't normally see vibration of the end of the end  
23 fitting itself in normal operation.

24 The fueling machine control system keeps  
25 a log of the positions of the end fittings, and it has

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1 got a homing system that allows it to basically latch  
2 on should the end fitting have deflected out of  
3 position.

4 DR. ROSEN: But you see no deflection.  
5 The cantilevered, it could be -- if there was some  
6 sort of forced vibration in the building or the --

7 MR. MILLARD: Yeah.

8 DR. ROSEN: -- it would be going like this  
9 all the time and you'd worry about fatigue eventually.

10 MR. MILLARD: Yeah, I know. We haven't  
11 seen anything like that. In part, I suspect because  
12 it's very stiff because it has to take the seismic  
13 loads from the fueling machine during seismic events.  
14 So the structural load or the structural strength  
15 we've got for that keeps it relatively --

16 DR. RANSOM: Does the refueling machine  
17 actually hang onto the fuel channels?

18 MR. MILLARD: The fueling machine is  
19 ported off the bridge, but it's spring loaded, and  
20 it's in several axes on the bridge and clamps firmly  
21 onto the channel with its 60,000 pounds of force. So  
22 it is very firmly clamped onto the end of the channel,  
23 and then there's a lock that goes in, physically  
24 locking it on to make sure it can't move while it's  
25 part of the pressure boundary.

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1                   This is just an end view of the reactor  
2 showing the STS-2 shutdown nozzles here, which is way  
3 up into the reflector region and down into the  
4 channels and the numbering of the channels. This  
5 numbering also appears on the reactor face so that  
6 your reactor operators can see it while they're  
7 fueling through their TV camera views.

8                   So apart from the physics staff telling  
9 them which channel to refuel and seeing the automatic  
10 sequences to go to that channel, these numbers then  
11 appear later on you'll see in the picture of the  
12 reactor face.

13                   This is the more detailed picture of the  
14 fuel channel assembly. You can see there's a groove  
15 here on the end fitting that we clamp onto here, and  
16 then we have a sealed face on the outside here that we  
17 seal with a metallic seal between the --

18                   DR. WALLIS: So isn't this a symmetrical  
19 end then?

20                   MR. MILLARD: You mean both ends?

21                   DR. WALLIS: Or maybe it's just the  
22 numbering scheme that's not symmetrical.

23                   DR. ROSEN: I was looking at the face.  
24 Go back then.

25                   DR. WALLIS: You've got eight on one end

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1 and nine on the other. It's just the numbering  
2 scheme. It's not symmetrical. Okay. Did you miss  
3 out number nine, do you? There must be a nine under  
4 the J.

5 MR. MILLARD: Yes.

6 DR. WALLIS: Okay.

7 MR. MILLARD: Yeah, there's a nine under  
8 the J.

9 DR. WALLIS: Okay. That's all right.

10 MR. MILLARD: So basically you can see our  
11 restraint here going into the fueling tube sheet. The  
12 bellows here, which are seal welded on the outside,  
13 and then attached to the end, the end fitting. The  
14 shield plug here, which is the main fuel support which  
15 we pull out to move the fuel string and change  
16 bundles, and the closure plug at this end that we take  
17 out with the central stem. You can't really see the  
18 jaws in this view though. It's much too small.

19 MR. LEITCH: Does the unit continue to  
20 operate at full power while this is ongoing?

21 MR. MILLARD: Yes, yes.

22 MR. LEITCH: And must there be some  
23 adjustments in reactivity after you make one of these  
24 moves or is what you're doing on any given day so  
25 small that you can't really see it?

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1 MR. MILLARD: The operator doesn't  
2 normally do anything to adjust the reactivity, but the  
3 zone controls themselves may adjust automatically,  
4 slightly to compensate should you end up with --  
5 because as you refuel over a day when you're refueling  
6 several channels, you're refueling in different parts  
7 of the core. So you're changing the core balance. So  
8 the zone controls will automatically adapt for that.

9 MR. LEITCH: And where does the  
10 operator -- where is he positioned? Does he have any  
11 unusual radiation exposure while doing this operation?

12 MR. MILLARD: Not really. The operator is  
13 in the control room.

14 MR. LEITCH: So this is all done remotely  
15 then?

16 MR. MILLARD: It's all done remotely.  
17 Most stations do send operations staff on walk-  
18 throughs through the reactor building where they'll  
19 look at some aspects of the system while it's  
20 operating, but they don't go anywhere near the reactor  
21 face.

22 MR. LEITCH: Sure, yeah.

23 MR. MILLARD: They'll be looking at the  
24 process system underneath the air lock and some other  
25 parts of the system, but they won't go into the actual

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1 radiation zone.

2 DR. ROSEN: You just said something that  
3 surprised me. That is that this operation is  
4 controlled from the main control room. It's not a  
5 separate refueling control room.

6 MR. MILLARD: Correct. It's controlled --

7 DR. ROSEN: I misunderstood that.

8 MR. MILLARD: Yeah, because the main  
9 control room under control of the main reactor  
10 operator. I'll show you later a picture showing you  
11 where the fuel handling panel sits and the fuel  
12 handling operators sit.

13 MR. LEITCH: Is there a TV monitoring then  
14 of the engagement?

15 MR. MILLARD: Yes.

16 MR. LEITCH: Okay.

17 MR. MILLARD: So we have TV monitoring and  
18 all the redundant sensors on the refueling machine  
19 itself.

20 MR. LEITCH: Okay. Thanks.

21 MR. MILLARD: So we've got drive sensors,  
22 redundant sensors, and we've got the TV picture.

23 DR. WALLIS: This feeder connection in  
24 this drawing looks like a bracket rather than a pipe.

25 MR. MILLARD: This one.

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1 DR. WALLIS: Yeah, what is that?

2 MR. SIEBER: That's the feeder connection.

3 DR. WALLIS: Yeah, but it's not a pipe  
4 that's welded on. It's a bracket of some sort.

5 MR. MILLARD: Yeah, the pipe gets welded  
6 on here. We're actually doing some detailed design  
7 optimization in this area of the port area.

8 MR. SIEBER: That's a cut-away view.

9 MR. MILLARD: So this is a cut-away view  
10 across our port. Just trying to minimize the pressure  
11 drop that's now as part of our detailed design work.

12 DR. WALLIS: So it's not just the pipe  
13 which is welded directly to the pressure tube.  
14 There's something else there.

15 MR. MILLARD: This one shows a bolted  
16 connection.

17 DR. WALLIS: Yeah, something else there.  
18 Okay.

19 MR. MILLARD: So the fuel channel  
20 interfaces --

21 DR. WALLIS: Why do you need a bolt if  
22 you've got a welded?

23 MR. MILLARD: This one goes back in many  
24 ways to our CANDU 6 Pickering-Bruce history. All of  
25 our historical CANDUs have been bolted at this place

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1 with metallic seals.

2 DR. WALLIS: So it's not a weld. it's a  
3 bolted, sealed connection that can be disconnected.

4 MR. MILLARD: And we considering going  
5 back to bolting in this region because we think we can  
6 get some advantages from it.

7 MR. SIEBER: It makes it easy to replace  
8 pressure tubes.

9 MR. MILLARD: Yes.

10 MR. SIEBER: You know, because you just  
11 undo the bolts, and it slides right out. Otherwise  
12 you've got to cut the pipe.

13 MR. MILLARD: Yes.

14 DR. WALLIS: So it's yet another place  
15 where there is a seal.

16 MR. SIEBER: Yeah.

17 MR. MILLARD: Yes.

18 MR. SIEBER: It's a potential leak.

19 MR. MILLARD: It's one of the few seals  
20 we've actually got.

21 DR. SHACK: Is that a metallic seal?

22 MR. MILLARD: Yes, it is metallic.

23 DR. WALLIS: Well, the seal, there are a  
24 lot of places where there are pressure boundaries  
25 which are not welded.

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1 MR. MILLARD: yes, yes.

2 DR. WALLIS: You may call some of them  
3 seals. Others are plugs.

4 DR. ROSEN: This one has a gasket. It's  
5 a gasketed seal.

6 MR. MILLARD: Yes, it is a gasketed seal.

7 DR. ROSEN: But it 's not very big. It's  
8 two inches.

9 MR. MILLARD: Yeah.

10 MR. SIEBER: Now, what keeps the fuel from  
11 just walking right back out of the pressure tube?

12 MR. MILLARD: It's basically the shield  
13 plugs which are latched in place.

14 MR. SIEBER: But that's way at the end.  
15 You've got --

16 MR. MILLARD: Both ends.

17 MR. SIEBER: -- a pretty long distance  
18 here between the calandria tube sheet where the fuel,  
19 the active fuel starts and the end of that plug. That  
20 looks --

21 MR. MILLARD: Oh, you mean the feeder here  
22 and here.

23 MR. SIEBER: -- like there would be three  
24 or four feet sticking back. So why doesn't the  
25 fuel -- you know, you've got a lot of flow going

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1 through there. Why doesn't the fuel sort of follow  
2 the flow?

3 MR. MILLARD: The fuel does follow the  
4 flow. Normally it's held in place by these shield  
5 plugs, fuel hard against the downstream shield plug  
6 which is latched in place and with a gap on the  
7 upstream shield plug. And then when you start to  
8 fuel, when you fuel from downstream, when you take out  
9 the plug, the whole fuel stream follows the plug  
10 down.

11 MR. SIEBER: Okay.

12 MR. MILLARD: And then when you push the  
13 shield plug back in place, the string goes back with  
14 it.

15 MR. SIEBER: And you were getting field  
16 growth, assembly growth while burn-up is proceeding.

17 MR. MILLARD: Yes.

18 MR. SIEBER: And that's what the gap is  
19 for. I take it the gap is maybe an intercept, a  
20 couple of centimeters.

21 MR. MILLARD: About an inch. Mark  
22 probably knows or Victor will probably remember the  
23 gap.

24 DR. WALLIS: That's why you have holes in  
25 the shield plug, to line up with the holes in the

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1 liner tube (phonetic).

2 MR. MILLARD: Yes, as we pull it back out.

3 MR. SIEBER: Okay. that's not important  
4 if you don't know.

5 MR. SNELL: Just to clarify, Victor Snell  
6 speaking. The gap is about an inch or two. One of  
7 the reasons of the gap, in a loss of coolant accident,  
8 you want to make sure that the expansion of the fuel  
9 stream isn't constrained by the two shield plugs.

10 MR. SIEBER: Right. Okay. Thank you.

11 MR. MILLARD: So the fuel channel is  
12 restrained, which reacts the fueling loads and the  
13 seismic loads because the biggest seismic loads that  
14 the fuel channel end fitting sees are when the fueling  
15 machine is attached. It has got this removable shield  
16 plug which locates the fuel string itself. It has got  
17 removable closure plugs which provide the pressure  
18 boundary, and it has got this end fitting interface  
19 which allows the head to latch on and clamp to it,  
20 acidual (phonetic) faced with a seal to allow us to  
21 extend the pressure boundary out into the fueling  
22 machines.

23 MR. SIEBER: And I take it for the  
24 standard design the seismic loading, I assume, would  
25 be a .3 G?

1 MR. MILLARD: We've got a lot of stuff  
2 going on to do with seismic, particularly to do with  
3 one site, but I'm not sure how much I'm supposed to  
4 say to do with that. I know our standard design  
5 reference was .3 G, but we'd be happy at looking at  
6 some higher loads to do with specific site spectra.

7 MR. SIEBER: Okay, but the standard design  
8 will have a standard seismic loading assumption which  
9 would apply to a majority of sites, I presume, and  
10 then you would have to do special work, special  
11 analysis for a seismically active site.

12 MR. MILLARD: I have a suspicion that some  
13 of the special work may be done up front because of  
14 one customer.

15 MR. SIEBER: Okay.

16 MR. MILLARD: I should let Stephen answer  
17 that.

18 MR. YU: Well, we certainly apply the .3  
19 G as our equivalent to SSE adequate level, and the  
20 soil conditions, you know, to look at the range of  
21 site soil conditions, and we do the envelope for the  
22 standard design. I think, you know, there might be  
23 special issues that is being currently, you know,  
24 addressed like the northeast region on the high  
25 frequency special seismic problem.

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1 But as far as the Center of Design is  
2 concerned, that's the approach, no different than  
3 other reactor types.

4 MR. SIEBER: Thank you.

5 MR. MILLARD: So fueling, we've got our  
6 string of 12 fuel bundles. We normally take our  
7 radiated fuel downstream putting fresh bundles  
8 upstream, which allows us to use flow for fueling,  
9 which is much more gentle on the bundles.

10 We are capable of fueling mechanically to  
11 go the opposite way if we have to, but we try not to  
12 fuel mechanically on power.

13 We discharged the irradiated bundles by  
14 our fuel port going through the containment boundary  
15 into the bay in the reactor auxiliary building, which  
16 is the square building around the main reactor  
17 building.

18 We bring in new fuel via fuel ports also  
19 through the containment boundary.

20 CHAIRMAN KRESS: And these are our locks  
21 so that the containment is not ever really open?

22 MR. MILLARD: Yeah.

23 CHAIRMAN KRESS: It's always really  
24 closed.

25 MR. MILLARD: It's always really closed

1 with a series of multiple valves on each one that we  
2 shuffle through.

3 And the fueling machine, as we've  
4 discussed, is this movable Class I pressure vessel  
5 that either connects to the fuel ports and fuel  
6 channels and sequence, as well as we've also got some  
7 ancillary ports and some other equipment for  
8 maintenance.

9 DR. WALLIS: So this fueling machine is  
10 going up and down, reactor pressure down to zero  
11 several times a day.

12 MR. MILLARD: Yes, yes.

13 DR. ROSEN: And you can take it out and  
14 maintain it when you're done with the fueling for the  
15 day; is that right?

16 MR. MILLARD: Yes.

17 DR. ROSEN: And move it to a place where  
18 you actually can go in, go in and get at it with your  
19 hands.

20 MR. MILLARD: Yes. Basically you can move  
21 it into this maintenance lock. A shield door comes  
22 across and then locks out, and then maintenance staff  
23 can come in there, do maintenance. They can unbolt  
24 the head, take the head off to a maintenance facility  
25 and put in a new head. They can do general

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1 inspection. They can do servicing.

2 MR. SIEBER: Could you -- I guess the next  
3 slide probably covers it -- but tell us what the  
4 design basis accidents are related to the fueling  
5 operation?

6 MR. MILLARD: Yeah, I can quickly go  
7 through this. I know the bulk of the design basis  
8 accidents, but I should probably have one of our  
9 safety staff, Victor, actually go through them in more  
10 detail.

11 MR. SIEBER: Obviously you have a LOCA  
12 associated with it, but there's probably some  
13 mispositioning accidents.

14 MR. MILLARD: Yeah, there are  
15 mispositioning accidents to do with the potential for  
16 the fueling machine to contact end fittings as it  
17 moves across the face.

18 MR. SIEBER: Right.

19 MR. MILLARD: I'm usually more concerned  
20 with all of the safety features we've got in to make  
21 sure this never happened in the actual details of the  
22 accidents that are being postulated.

23 MR. SNELL: But just to answer the rest of  
24 the question, of course, in safety you ignore all of  
25 that stuff that Jullian has put in and you make sort

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1 of bounding assumptions -- Victor Snell speaking, by  
2 the way -- you assume -- I'm going to memory -- but  
3 you assume the fueling machine can back off from the  
4 reactor without closing the plug. You assume  
5 severance of the inlet and outlet hoses, which  
6 actually provide cooling to the fuel while it's in the  
7 fuel bundle. You look at accidents with the refueling  
8 machine off reactor where it loses cooling in your  
9 transfer from the reactor to the spent fuel port.  
10 That's about the range of things, I think.

11 We do look at seismic events for the  
12 fueling machine on reactor, which really imposes a  
13 design requirement on qualification of the fueling  
14 machine which is already mentioned.

15 DR. ROSEN: If you do take two hot bundles  
16 into the fueling machine and then back away from the  
17 face and then have your accident where your cooling  
18 is severed, your hoses are severed, you're going to  
19 end up with two hot bundles with no cooling. Am I  
20 right?

21 MR. SIEBER: Right.

22 MR. SNELL: In some of the earlier designs  
23 you would boil off the water in a fueling machine and  
24 then you'd damage the bundles in the machine over a  
25 period of I think tens of minutes if my recollection

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1 is correct. I believe on ACR there's backup cooling  
2 provided in the cooling machines in transit. So  
3 Biofueling Confront (phonetic), I believe, made  
4 improvement to the machine in that respect.

5 (No response.)

6 And there's also multiple errors that  
7 you've got, which is not tens of minutes. It's  
8 multiple errors because we've got ten tons of steel  
9 and water to heat up with the fuel load. so --

10 DR. ROSEN: Wait a minute now. Are we  
11 talking about just having two spent assemblies right  
12 fresh from the reactor --

13 MR. MILLARD: Yes.

14 DR. ROSEN: -- in the machine?

15 MR. MILLARD: Yes.

16 DR. ROSEN: And then the machine is  
17 disabled and loses cooling?

18 MR. MILLARD: Yes, yeah.

19 DR. ROSEN: Where does this ten tons of  
20 water come from? I don't get it.

21 MR. MILLARD: The fueling machine head  
22 mass of steel plus water is about ten tons. So you've  
23 got to heat up not just the water in the magazine, but  
24 the magazine shell itself, which is multiple tons.

25 DR. WALLIS: Do you have pictures of this

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1 machine somewhere in here?

2 MR. MILLARD: Yeah.

3 MR. SIEBER: The transfer coefficient  
4 between the fuel bundle and the machine walls isn't  
5 going to be very good with the water mix, and so the  
6 temperatures of the fuel bundle will probably go  
7 pretty high.

8 MR. MILLARD: The water doesn't get lost  
9 out of the fueling machine head for many hours  
10 normally because all of our connections are high up on  
11 the machine. So basically you can't drain down the  
12 fueling machine head below the level that the fuel  
13 sits.

14 MR. SIEBER: But it is boiling away.

15 MR. MILLARD: Yes, but it takes many hours  
16 to boil away.

17 DR. ROSEN: So if the hose is severed, the  
18 water spills out in the hoses, but that's all.

19 MR. MILLARD: Yeah.

20 DR. ROSEN: The water in the machine is  
21 still there.

22 MR. MILLARD: It's still there.

23 MR. SIEBER: I would have to look at that  
24 more carefully.

25 MR. MILLARD: We have multiple hose

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1 connections so we have redundant --

2 MR. SIEBER: Well, I would think that that  
3 would be an opportunity to exercise defense in depth.

4 MR. MILLARD: Yes. Now, the principal  
5 safety features on our fueling are well proven and  
6 have been developed over the years with the Canadian  
7 standard also being developed as we gain more  
8 information. Our pressure boundary components, we use  
9 ASME criteria and ASME code in full whenever we can,  
10 only enhancing it where we needed to, where there was  
11 a gap that wasn't covered. For instance, the NF  
12 support of the actual vessel, ASME doesn't take into  
13 account a moving vessel with median standards  
14 association codes governing those features, and we've  
15 got a lot of interlock, mechanical locks, and backup  
16 systems in there to make sure everything is safe.

17 And we've also got this benefit of lower  
18 reactor coolant activity because of the fact that  
19 we're able to take out defect bundles very promptly,  
20 which helps keep the reactor coolant system activity  
21 low, which makes maintenance easier.

22 MR. SIEBER: Could you tell us if there  
23 have been incidents or accidents with refueling  
24 machines in CANDU reactors of any design, and if so,  
25 maybe a simple characterization of what happened?

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1 MR. MILLARD: There have been a number of  
2 incidents primarily in the earliest CANDU reactors to  
3 deal with fueling machines. A number of them were to  
4 do with operator error of operators by passing out  
5 information. In subsequent reactors, interlocks were  
6 then improved to stop that happening.

7 For instance, many, many years ago in  
8 Pickering, I believe, they forgot to put a thing  
9 called a guide sleeve, which is a piece of tube which  
10 keeps the bore of the end fitting constantly going  
11 into the fueling machine.

12 MR. SIEBER: Right, right.

13 MR. MILLARD: Basically the channel  
14 closure is a larger diameter, this guide sleeve.

15 MR. SIEBER: Right.

16 MR. MILLARD: So this time they forgot to  
17 put the guide sleeve in, and then they were able to  
18 put a fuel bundle into that gap. It cost a lot of  
19 trouble to get over. The precautions to stop that  
20 ever happening again are a lot more rigorous, and  
21 there's detail of a lot of that stuff in the  
22 submission that we did.

23 MR. SIEBER: Okay. Thank you.

24 MR. MILLARD: As far as features to  
25 enhance safety, we've got our latching snout mechanism

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1 with additional safety lock to make sure that we can't  
2 unintentionally or have an unsafe release from the  
3 fuel channel to make sure RCA's integrity is always  
4 maintained.

5 We've got a lot of qualifications of our  
6 controls and instrumentation to make sure it functions  
7 properly following earthquakes, loss of coolant  
8 accidents or main steam line breaks.

9 We've got a seismically and  
10 environmentally qualified emergency water system to  
11 make sure we keep fuel cooling in the fueling machine  
12 head when we're off channel for those bundles to make  
13 sure we don't get into the boil-off state.

14 And we've also got special baskets for  
15 maintaining criticality because we've increased the  
16 enrichment over past CANDUs. We've got to have more  
17 features in for criticality protection. So we've got  
18 absorbing sleeves in all of our storage baskets and  
19 the same types of storage sleeves of steel sleeves in  
20 all of our magazines in new fuel and spent fuel in the  
21 fueling machine itself to make sure we have our  
22 criticality as well.

23 I can't go through all of the safety  
24 features, but in terms of the inadvertent release  
25 features, we have got the snout to end fitting

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1 clamping mechanism itself, the protection in that.  
2 We've got a safety lock which is totally passive in  
3 its operation and it's engaged by channel pressure.  
4 So operators can't override it to make things go  
5 wrong.

6 We've got these checks on the fueling  
7 machine snout and the general end fitting prior to  
8 removal of the channel closure in the first place, to  
9 make sure everything is okay.

10 We've got further interlocks on pressure  
11 and status of the safety lock. We've got another  
12 series of interlocks on the bridge drives and related  
13 brakes to make sure the bridge is locked into position  
14 when we're extending the pressure boundary.

15 We've got limited force of the carriage  
16 drives as well to make sure that the carriage has got  
17 the minimum chance of doing any damage. We've got a  
18 further check on partial channel blockage prior to  
19 installing the channel closures so that we make sure  
20 when we have fueled that we have fueled properly and  
21 we haven't inadvertently started to block the channel  
22 in any way, and then we've got further checks for  
23 integrity of the seal between the channel closure and  
24 the end fitting before we unclamp.

25 So we've got an excellent safety record so

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1 far to do with fueling. We've got over 400 years of  
2 operation with no accidents.

3 DR. FORD: That's really reactor years.

4 MR. MILLARD: Reactor years.

5 DR. ROSEN: That's how many fuel  
6 assemblies do you think you've actually transferred?  
7 Probably hundreds of thousands?

8 MR. MILLARD: It's hundreds of thousands.  
9 In the CANDU 6s alone it's 43,000 fueling cycles that  
10 we've been through. That's channels refueled. So  
11 over the other types of reactors, it's into the  
12 hundreds of thousands. So we've got a huge body of  
13 data to build on operational experience.

14 The CANDU 6 stations improved on the alley  
15 stations on their safety performance as I alluded to,  
16 and ACR is further built on in its design on the CANDU  
17 6 stations with more safety features and using a lot  
18 of data from the feedback system to further optimize  
19 the design.

20 In terms of the actual equipment, I'll  
21 give you a quick run-through, showing you the new fuel  
22 storage that we go through into new fuel transfer,  
23 into the fueling machine itself with its head, its  
24 carriage, its bridge, the catenaries, the fluid  
25 systems that supply through the catenaries and the

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1 control system into the spent fuel transfer system and  
2 into spent fuel storage, both there and dry storage  
3 because historically the CANDU plants take fuel out of  
4 the pay when it's cooled enough and moves it into  
5 long-term dry storage.

6 Basically new fuel starts in this secure  
7 storage and is only moved into the transfer room as  
8 required. So quantities are limited in that area, and  
9 as I said, we store the fuel with features to prevent  
10 inadvertent criticality even in the worst conditions.

11 DR. ROSEN: And all fuel assemblies are  
12 identical. You don't vary the enrichments or anything  
13 like that?

14 MR. MILLARD: All of our normal fuel is  
15 identical. The first load, as Peter talked about, is  
16 slightly different, but subsequent to that, once  
17 you're past that stage everything is the same.

18 DR. ROSEN: So there's no chance of a mix-  
19 up of a new bundle or anything. They're all the same.

20 MR. MILLARD: Yes. So then when the  
21 containment valve is closed, we inspect the fuel  
22 before we put it in. We load it into the transfer  
23 magazine, and then we close isolation valves and  
24 transfer the fuel across through containment into the  
25 fueling machine head.

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1                   This is a very rough schematic just  
2 showing we've got this loading trough, a loading ram,  
3 isolation valve, the magazine or isolation valves and  
4 a transfer tube going through.

5                   I show you a much more cluttered picture  
6 here from a CANDU 6 station. This is the magazine  
7 here. The ram is here. The trough is underneath this  
8 cover here, and these are simple manual controls for  
9 local operation of the thing. We've also got this  
10 hoist here which is used. So the staff don't need to  
11 pick up a bundle by themselves. They've basically got  
12 a grapple on the hoist that they use.

13                   MR. SIEBER: A magazine.

14                   DR. FORD: And that's the ten ton --

15                   DR. WALLIS: No, no, no. It's outside  
16 containment.

17                   DR. FORD: Oh, okay.

18                   MR. MILLARD: There's very little  
19 capacity.

20                   DR. FORD: This isn't the fueling machine  
21 yet. This is this exact --

22                   MR. MILLARD: No, this is just nuclear  
23 transfer to get it in the first place and to get it  
24 somewhere where we can do our final inspection to make  
25 sure there has been no damage between the fuel storage

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1 and before it goes in.

2 The fueling machine itself, we've got the  
3 head, which is a Class 1 pressure vessel, which has  
4 got a snout assembly with drives in it to connect to  
5 the channels and ports. It has got separators which  
6 are fingers to both sense the movement of things going  
7 through the snout and also to provide some separation  
8 motion so we can split apart fuel strings before we  
9 retain magazines.

10 There's the magazine which holds fuel and  
11 tools, and we have got a latching ram assembly which  
12 is a compound ram which moves the fuel and hardware  
13 around.

14 Then there's a carriage that supports the  
15 head and gives it local motions, including the motions  
16 onto the reactor face and back off.

17 There's the bridge which supports the  
18 carriage and also is used to support inspection and  
19 maintenance. It is used as a big lift basically  
20 during a lot of the shutdown inspections and initial  
21 build of the reactor.

22 We've got the catenary system, which is  
23 for power and fluid systems, which is all redundant.  
24 We've got the control system with viewing and safety  
25 interlocks, and we've got this process system for our

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1 pressure control and cooling to go between the  
2 different pressure states on the reactor and lower  
3 pressure on the fuel transfer ports.

4 This is just a high level picture with a  
5 lot of the walls cut away showing the tracks inside  
6 the maintenance lock, the catenary itself, the fueling  
7 machine head, the carriage, the bridge system here,  
8 and the columns which support the bridge.

9 This is an equivalent CANDU 6 fueling  
10 machine which is a lot more complex on the structure  
11 on it because it uses all hydraulics to do with it.  
12 So there's a lot of idle controls here instead of  
13 electrical controls, but you can see isolation valves  
14 on the site of the fueling machine here. You can just  
15 see the magazine in here. You can see the boundary of  
16 it, and you can almost see the snout there and see the  
17 round (phonetic) here.

18 And then there's the catenary here with  
19 fluid and electrical connections going across into the  
20 maintenance lock. This is the shield door area where  
21 the shield door being out of the view on this site,  
22 and you can see the shield cabinets here with just a  
23 small bit of end fitting sticking out.

24 DR. WALLIS: Now, this refuel operation,  
25 does the operator just sort of do something to

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1 initiate it and then all of the sequence of events  
2 occur automatically or does the operator have to  
3 initiate each one of them in sequence or what?

4 MR. MILLARD: Certain sequences happen  
5 automatically, but there are certain safety critical  
6 ones which where a pause is forced, and in many  
7 instances the reactor operator has to come in and say,  
8 yes, it's okay to, for instance --

9 DR. WALLIS: To move on.

10 MR. MILLARD: -- reach the pressure  
11 boundary and, yes, it's okay to start moving fuel  
12 through the core. So the reactor operator knows at  
13 that time so if there is a reactivity transient, he  
14 can see it. He can see the things happening.

15 So it's basically under the control of the  
16 reactor operator with the automatic sequences just  
17 being used to give more consistency between them.

18 DR. ROSEN: Is there constant  
19 communication in the control room between the  
20 operating staff and the fueling staff?

21 MR. MILLARD: yes.

22 DR. ROSEN: Where the fueling staff says,  
23 "Now, we're going to latch onto so-and-so and so-and-  
24 so"?

25 MR. MILLARD: Yes.



1 DR. ROSEN: And the plant operators  
2 outside the fueling staff say, "Yes, I understand."

3 MR. MILLARD: You can do it.

4 DR. ROSEN: "If you're going to latch onto  
5 so-and-so, please go ahead."

6 And the other guy says --

7 MR. MILLARD: Yes.

8 DR. ROSEN: -- "Roger that. I'm going to  
9 go ahead."

10 MR. MILLARD: Yes. It's very much under  
11 the control of the main operator, as I'll show you in  
12 a picture we've got later. They are basically side by  
13 side in the control room.

14 DR. ROSEN: So it's not -- although it's  
15 in the same room, it's not proceeding like it's  
16 separate from the main operation.

17 MR. MILLARD: No.

18 DR. ROSEN: It is the operation of the  
19 station.

20 MR. MILLARD: Yeah.

21 DR. ROSEN: It's what the station is doing  
22 then.

23 MR. MILLARD: Yes, and it's basically the  
24 station is always under control of the main operator  
25 and the fuel handler.

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1 This is just a cut-away view of the ACR  
2 fueling machine head to make it slightly easier to see  
3 the magazine here with its tubes, which also provides  
4 for criticality protection and the ram sticking out  
5 the back.

6 And this is the ram.

7 DR. ROSEN: Are these matters just good  
8 practice , what we just discussed, or are they  
9 required by regulation? The formal communications  
10 and the control of these manipulations. How deep does  
11 that go in your regulatory scheme?

12 MR. MILLARD: I'm not actually sure how  
13 deep that goes. I know there's a lot of sign-off, and  
14 I know the qualification of the operators includes  
15 control of that, but I'm not sure where it's  
16 enshrined.

17 DR. ROSEN: See, what I'm getting at is  
18 these are reactivity manipulations.

19 MR. MILLARD: Yes.

20 DR. ROSEN: And they get the highest level  
21 of attention in our system.

22 MR. MILLARD: Yes.

23 DR. ROSEN: But they are clearly of a  
24 different kind than we have, but they are  
25 fundamentally change in delta K, and that means rigid,

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1 riveted attention on it.

2 MR. MILLARD: Yes.

3 MR. SNELL: Let me give you a somewhat  
4 incomplete answer to your question -- Victor Snell  
5 again -- because a lot of this goes over into  
6 operating utilities.

7 The way it works in Canada, an operating  
8 utility has to prepare operating policies and  
9 procedures and submit those to the regulatory agency  
10 for review and approval before they can operate and  
11 become part of the plant license, and those would have  
12 to describe the responsibilities of the various  
13 operators in the control room.

14 I believe what Jullian is saying is  
15 correct, but I think to be 100 percent sure, you need  
16 to actually look at what a particular utility does.  
17 So the way the regulation is done is through approval  
18 of the operating policies and principles that a  
19 utility submits to our CNSC.

20 Once they're approved, they're bound to  
21 them, and they would describe the relationship that  
22 Jullian is describing.

23 DR. ROSEN: And those policies would then  
24 be embodied in practices which are procedures.

25 MR. SNELL: Well, they're part of the

1 license, and they would be --

2 DR. ROSEN: And then they become part of  
3 the license which they are required to follow.

4 MR. SNELL: That's correct.

5 DR. ROSEN: And so any inspector could  
6 come in and see if they're following at any time.

7 MR. MILLARD: And they basically have  
8 administrative logs and computer logs in the fueling  
9 machine systems showing all of the operations of the  
10 plant.

11 The spent fuel port in the maintenance log  
12 also is an extension of local pressure boundary there,  
13 and basically we transfer a straight through into the  
14 bay in water. So for ACR it's waterborne transit all  
15 the way. So there's no cooling issue at all in that.

16 And as was talked about earlier, we're  
17 going straight into baskets as part of that process,  
18 moving the fuel from horizontal into the vertical  
19 position so we can store the fuel in basically a  
20 larger --

21 DR. ROSEN: How can you do that? I mean,  
22 you can't -- grabbing it with a tool or anything, it  
23 has got to have some sort of an up ender that goes  
24 like that doesn't it?

25 MR. MILLARD: The current plants have got

1 a relatively simple up ender. We're still actually in  
2 detail design of our ACR equivalent because as part of  
3 that we have to drop it down into a solid tube. In  
4 the current ones they can go upright, and they're only  
5 going into a partial tube in the dry store baskets  
6 whereas we have to go into a solid tube, but we have  
7 to do it very gently.

8 So we don't have all of the detailed  
9 design of that sorted out just now.

10 DR. ROSEN: But in the current plants it's  
11 some kind of tray into which this bundle is pushed,  
12 and then it's pinned at one end presumably in a  
13 hydraulic arrangement or a check drive that pulls it  
14 upright.

15 MR. MILLARD: That pulls it upright.

16 MR. LEITCH: Jullian, if I'm getting the  
17 picture correctly, there are really two fueling  
18 machines, one in each end.

19 MR. MILLARD: Yes.

20 MR. LEITCH: Now, when you're discharging  
21 the fuel versus inserting new fuel, do you have to  
22 change the positions of those machines or the one  
23 machine can serve both functions?

24 MR. MILLARD: Each machine can serve both  
25 functions.

1 MR. LEITCH: Okay.

2 MR. MILLARD: Many of the utilities try to  
3 do on a single day everything all in one direction,  
4 which our physics colleagues don't always cooperate on  
5 that.

6 MR. LEITCH: So there's no detrimental  
7 effect then with running for a day or so with only ten  
8 bundles instead of twelve in that particular tube?

9 MR. MILLARD: No. We always take out and  
10 put in one channel at a time.

11 MR. LEITCH: Okay.

12 MR. MILLARD: We don't run the machines  
13 independently.

14 MR. LEITCH: Okay.

15 MR. MILLARD: We do take out and put in at  
16 the same time. So we always keep 12 bundles.

17 MR. SIEBER: You actually have 14 during  
18 that operation.

19 MR. MILLARD: On CANDU 6 they end up with  
20 more, but for ACR, we don't.

21 MR. SIEBER: Oh, really?

22 MR. MILLARD: Because the enriched fuel we  
23 take out before we put back.

24 MR. SIEBER: Okay.

25 MR. MILLARD: So it's a maximum of 12 for

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1 ACR.

2 MR. SIEBER: But once you get outside the  
3 moderator area, other than the difficulty of making  
4 the calculations, you're pretty much guaranteed  
5 criticality.

6 MR. MILLARD: yes.

7 MR. LEITCH: Now, I'm picturing the  
8 machine on one end getting out of kilter with the  
9 machine on the other end. Is that possible or is  
10 there some kind of interlocks other than just  
11 administrative to prevent that from occurring?

12 MR. SIEBER: They're both in the same  
13 tube.

14 MR. MILLARD: They're controlled from the  
15 same control room with redundant controls, and there  
16 are usually two fuel handling operators watching to  
17 making sure that you're on the right place with also  
18 camera views from both ends, which show you which  
19 channel you're on.

20 And there's a TV monitor apart from just  
21 being on the control panel in front of the fuel  
22 handling operator. There's a bigger monitor higher up  
23 so other people in the control room can see are they  
24 getting out of kilter.

25 It's more an economic penalty if they did

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1 get out of kilter because of the reactivity change  
2 from one channel is relatively small So you're  
3 just --

4 DR. ROSEN: What do you mean by "out of  
5 kilter"?

6 MR. MILLARD: Instead of being one  
7 channel, if someone tried to put new fuel into one  
8 channel while taking fuel out of another channel, for  
9 instance, adjacent channels.

10 DR. ROSEN: Well, it wouldn't work, right?  
11 I mean the channel that you were trying to put it in,  
12 there wouldn't be any room.

13 MR. SIEBER: You would have to push hard.

14 MR. MILLARD: The fuel would go into the  
15 channel, but it wouldn't go into the core area, and  
16 then the shield plug wouldn't go back into place. It  
17 would be basically just drop out, but it doesn't have  
18 enough force to do any damage.

19 DR. ROSEN: Now, on the other end you  
20 could take some bundles out and not replace them.

21 MR. SIEBER: And you could forget about  
22 it.

23 MR. MILLARD: Yes.

24 MR. SIEBER: You could forget about it,  
25 and that would be --

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1 DR. ROSEN: But that would just be an  
2 economic penalty.

3 MR. SIEBER: Well, to achieve 100 percent  
4 power you've got to raise the power someplace else so  
5 you end up with a --

6 MR. MILLARD: But I gather our physics  
7 people would rather we didn't operate with empty  
8 channels or partial empty channels.

9 MR. SIEBER: Yeah, right.

10 DR. ROSEN: The physics people are really  
11 in charge of this operation.

12 MR. MILLARD: Yes.

13 DR. ROSEN: They give you a fueling order,  
14 I assume of some kind.

15 MR. MILLARD: Yes.

16 DR. ROSEN: A written document that says  
17 or a computer document that says, "Do this."

18 MR. MILLARD: "Do this."

19 DR. ROSEN: And then the main control room  
20 chief, the unit op. station manager, or the shift  
21 manager says, "Okay. This looks like a valid order  
22 from the right people; seems reasonable to me, and  
23 we'll do this," and he gives it to the fueling people.

24 MR. MILLARD: Yeah, and then he watches  
25 them do it.

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1 DR. ROSEN: So there's a chain of command  
2 here.

3 MR. MILLARD: I know, and he also watches  
4 them doing it at key stages to make sure they're  
5 opening the right channels. So there are levels of  
6 checks and balances to make sure you don't start doing  
7 it on different channels.

8 MR. LEITCH: Earlier you talked about this  
9 operation proceeding perhaps four days a week. Is  
10 that four around-the-clock days or is it done in four  
11 or five hours a shift?

12 MR. MILLARD: Most of the plants do it  
13 during a day shift. They have two days of fueling, a  
14 day of maintenance, two days of fueling. Bruce  
15 operates more -- the Darlington stations just now  
16 operate around the clock, but they are larger cores,  
17 and they have more flexibility in their maintenance,  
18 but for ACR we'd be following CANDU 6 Pickering type  
19 practice.

20 DR. ROSEN: Graham's question is an  
21 interesting and useful one, and I don't think I got  
22 the answer I expected. For that day that they're  
23 refueling, do they work a 24-hour day?

24 MR. MILLARD: No.

25 DR. ROSEN: How many hours during the day

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1 of the day that they're actually working?

2 MR. MILLARD: From memory, we need to  
3 check, but I think it's around about four hours of  
4 actual operation. I would need to dig back through  
5 some of our operational stuff.

6 DR. ROSEN: So on a fueling day of 24  
7 hours, they only are actually moving fuel for four  
8 hours of that 24.

9 MR. MILLARD: Yeah. Yeah, because you  
10 don't get a full seven and a half hour shift of actual  
11 operating time in the breaks and the time going to and  
12 from the control room.

13 DR. ROSEN: And there's plenty of time to  
14 take your time is the other time I'm interested in.

15 MR. MILLARD: Yes.

16 DR. ROSEN: This operation, while it must  
17 proceed, can proceed in an orderly manner.

18 MR. MILLARD: Yes.

19 DR. ROSEN: A measured pace.

20 MR. MILLARD: Yeah, and if you don't do  
21 things one day there's enough reactivity control that  
22 you can do it in the next. So you've got multiple  
23 days of what's normally referred to as shim that you  
24 can use up if you want to, if you don't fuel for any  
25 reason.

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1 MR. SIEBER: What's the burn-up in  
2 megawatt days per metric ton of the typical spent  
3 bundle?

4 MR. MILLARD: For ACR, Peter can probably  
5 confirm, but I think it's 20.5.

6 MR. CHAN: About 20.5 or 20,500 megawatt  
7 day per ton, somewhere.

8 MR. SIEBER: Thank you.

9 MR. MILLARD: And typically a lot of our  
10 stations use dry store more for economic reasons for  
11 taking the fuel out of the fuel bay for a certain  
12 period.

13 The spent fuel transfer basically is done  
14 under water with containment valves using flow to move  
15 the fuel across so that we've got very gentle movement  
16 with a series of containment valves.

17 And then we move into these baskets which  
18 are stored in racks. The exact shape of some of this  
19 basket structure is currently the optimized in detail  
20 design. So you may see some changes as the years go  
21 on in the process of the application, well, over the  
22 next year before the ACD submission goes in.

23 MR. SIEBER: Is there any reason why you  
24 chose to put a hat shaped basket in a rectangular  
25 slot?

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1 MR. MILLARD: This picture is actually  
2 quite old. I think it was done originally for  
3 simplicity of the seismic support or for the basket,  
4 for some particularly high seismic zone areas.

5 MR. SIEBER: Thank you.

6 MR. MILLARD: The fuel handling operators,  
7 basically the senior nuclear operator is in control.  
8 He's got to give approval when we're clamping onto the  
9 channel, when we take the channel closures out, when  
10 we're moving or transferring the fuel, or when there  
11 are any manual operations going in there, when they  
12 divert from sequences for any reason.

13 DR. ROSEN: Is your senior nuclear  
14 operator equivalent to our senior reactor operator or  
15 a unit supervisor or shift supervisor? Why is his  
16 equivalent here? Do you know? Is he the top guy on  
17 the shift, the highest level or the next highest?

18 MR. MILLARD: I'm far from the expert on  
19 the operator. Stephen, do you?

20 MR. YU: I believe they're equivalent.

21 DR. ROSEN: I didn't understand.

22 MR. YU: I believe the two are equivalent.

23 DR. ROSEN: Senior nuclear operator is the  
24 same as senior reactor operator in the U.S.?

25 MR. YU: In U.S., yes.

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1 MR. MILLARD: Yes. And fuel handling  
2 panel operators. There's a fairly rigorous program of  
3 about 18 months before they can actually do anything,  
4 and even then they're under the control of someone  
5 else.

6 This is a view of the control room from  
7 Qinshan showing the central table and the panels for  
8 the main reactor control, but showing the fuel panel  
9 on one site. Basically it is split down the middle  
10 here with one site being for one fueling machine and  
11 the other side for the other fueling machine, and  
12 there's a back-up TV screen at the top here.

13 Some of the plants have actually put in  
14 bigger displays to give a better view of what's going  
15 on.

16 MR. LEITCH: So there's no conflict  
17 between fueling and normal reactor operations? For  
18 example, if the plant trips while this, there may be  
19 distractions, but there's no restraint with regard to  
20 doing it.

21 MR. MILLARD: Well, no. Basically  
22 everything happens as it normally would. The reactor  
23 operator is in control of it all.

24 DR. ROSEN: What do you mean it happens as  
25 it normally would? They continue fueling or --

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1 MR. MILLARD: No. Fueling stops. Fueling  
2 stops. If they haven't taken a closure plug out, they  
3 wouldn't take it out, and if anything, they would try  
4 and get the fueling machine off and clear. If the  
5 fueling machine is in operation, they would stop until  
6 a safe time, until they're told to bottle up that  
7 channel and get the closure plug in.

8 MR. LEITCH: Is the fuel machine provided  
9 with normal AC power or is there any kind of  
10 emergency power supply?

11 MR. MILLARD: Typically they have been run  
12 off Class III. There's still a debate going on for  
13 ACR reading through the U.S. regulations if where we  
14 will end up, and so I'm not quite sure where we are,  
15 if we've deviated yet on that.

16 So the fuel handling operators follow many  
17 practices to guard against errors. They never start  
18 fueling unless they've got full increment redundancy  
19 available on the redundancy inside the fueling  
20 equipment. They never perform operations on their RAD  
21 until they have been tested first and rehearsed, and  
22 there's a high emphasis on human performance and  
23 qualification with automation used for consistency,  
24 and we've got extensive software checks and software  
25 interlocks to do with the automation, and independent

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1 and separate interlocks on hardware to make sure  
2 things aren't done wrong.

3 Now, the maintenance is done on line.  
4 We've got full redundancy in everything. We've got a  
5 predictive preventive maintenance program going on,  
6 and there's a fuel emission maintenance area outside  
7 that is used for all of this maintenance. So  
8 basically there are no scheduled outages for fueling  
9 purposes. It's all for maintenance of the other  
10 equipment because the fuel handling equipment tends to  
11 be used in outages for getting at the reactor phase.

12 So the on power refueling capability of  
13 ACR reactors completely splits us from fueling  
14 requirements on our outages. It gives us a lot of  
15 flexibility and safety margins. It gives us local  
16 reactivity, removal of defect fuel. We've got  
17 computer control and automation to make sure  
18 everything happens safely and with optimum fuel usage,  
19 and we've got defense in depth all the time with  
20 multiple barriers.

21 DR. RANSOM: When defective fuel is  
22 detected, what do you, remove the entire channel?

23 MR. MILLARD: On current stations they  
24 remove the entire channel, but for ACR I suspect we  
25 are going to end up taking out the individual bundles

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1 because of the different performance of fuel. Peter  
2 could probably explain that better.

3 There's also a bigger economic penalty on  
4 ACR than on the previous natural uranium CANDUs where  
5 fuel is extremely cheap.

6 DR. RANSOM: You have a method, I guess,  
7 for finding out which bundle it is in the channel  
8 that's leaking?

9 MR. MILLARD: We start off by telling down  
10 to the channel, and even in doing so because we know  
11 the high stress title in the fuel, which is during  
12 fueling shifts, we know pretty well which bundle is  
13 going to be because it will be one of the earlier  
14 bundles going through the channel.

15 When we actually pull the fuel out through  
16 the fueling machine head, we have got detection  
17 associated with the fueling machine head, and we can  
18 also see the drop on defect gases coming through the  
19 reactor coolant systems itself, through measurement in  
20 the headers.

21 So we can tell when the defect bundle  
22 leaves the core, as well as looking to see defect  
23 bundles in the fueling machine itself.

24 And then we've got further diagnostics  
25 going through fuel transfer so that we can handle it

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1 appropriately and make sure the defect gases don't get  
2 into the bay.

3 DR. RANSOM: Just out of curiosity, a  
4 fueling machine can take out more bundle at once, more  
5 than one bundle at once or --

6 MR. MILLARD: It normally handles pairs.  
7 It's capable of emptying a complete channel because it  
8 empties complete channels during shutdowns for  
9 inspection of panels.

10 DR. RANSOM: And it also has sort of a  
11 Gattling type cartilage, I guess, that you can load  
12 them into?

13 MR. MILLARD: Yes, yes. So we designed to  
14 take out a complete channel in pairs.

15 MR. LEITCH: I don't see any provision for  
16 recycling a fuel bundle; is that correct, or did I  
17 miss something? Once it's out, it's out?

18 MR. SIEBER: Right.

19 MR. MILLARD: Normally once it's out we  
20 have got the ability to put shield plugs back and  
21 forth between it, but the fuel staff don't want us to  
22 put fuel back.

23 CHAIRMAN KRESS: Is all of your spent fuel  
24 storage on site at every reactor? I mean, you don't  
25 have a central storage at Yucca Mountain?

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1 MR. MILLARD: No, we don't have the  
2 equivalent of a Yucca Mountain. Each station up to  
3 now has been taking care of their own stuff. The  
4 multiple unit stations have got central facilities  
5 associated with those multiple unit stations.

6 So, for instance, the Bruce site has got  
7 one dry store facility, as has the Pickering site.

8 CHAIRMAN KRESS: Are those essentially  
9 like the dry storage units?

10 MR. MILLARD: Yeah, and also Pickering has  
11 got some centralized bays where it can move things  
12 out.

13 CHAIRMAN KRESS: I guess we'll now move on  
14 to the computer code validation adequacy.

15 MR. RICHARDS: Yeah, I'm just going to  
16 have a brief overview on our computer codes and  
17 validation adequacy. I'll start by talking about our  
18 software quality assurance program, SQA program; talk  
19 a little bit about our validation methodology; then  
20 talk about what we call our industry standard tool set  
21 and the key ACR computer codes.

22 I can't concentrate on a range of codes.  
23 So I've chosen thermal hydraulics as an example in my  
24 presentation. So I'll focus in on thermal hydraulics  
25 later in the presentation, and I'll give some examples

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1 of CATHENA validation, which is our thermal hydraulics  
2 computer code.

3 The software quality assurance program  
4 that we operate under are under predefined QA  
5 procedures and they're based on the Canadian Standards  
6 Association, CSA, quality assurance of analytic,  
7 scientific and design computer programs for nuclear  
8 plants. That is N-286.7, published in '99.

9 And subsequent to this, ACL published its  
10 own quality assurance manual which is compliant with  
11 the standard, and that was revised again in March  
12 2001.

13 CHAIRMAN KRESS: When we talk about QA and  
14 validation of software here, the staff, NRC staff,  
15 focuses very strongly on the process, how it is put  
16 together and the specifications, rather than final  
17 product, these standards here.

18 MR. RICHARDS: They're very process  
19 driven. So if you look at like the design, you'll  
20 start out with the problem definition. You'll have a  
21 development plan, and you'll go through the stages  
22 until you get to design and then coding, and then each  
23 one of those will have a verification step.

24 CHAIRMAN KRESS: Okay. That's very much  
25 like what we do here.

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1 MR. RICHARDS: Yeah.

2 DR. APOSTOLAKIS: Well, but they do more  
3 than we do.

4 CHAIRMAN KRESS: Well, I'm waiting for --

5 DR. APOSTOLAKIS: I believe you use some  
6 formal language. At least for Darlington, the  
7 specifications are formulated in terms of formal  
8 language; is that correct?

9 MR. RICHARDS: For the computer programs  
10 we use for safety and licensing analysis, it's done  
11 under the standard. Now, Darlington, the OPG, Ontario  
12 Power Generation, they've developed a manual similar  
13 to what we have, and it is quite detailed, quite  
14 prescriptive on the things that you have to do through  
15 the software development cycle and the documentation  
16 you must have in place for the user.

17 MR. LANGMAN: Excuse me, Dave. Vince  
18 Langman, ACR.

19 I think what you're referring to is the  
20 safety critical software work that Darlington does,  
21 and that is a very algebraic, formal verification.

22 DR. APOSTOLAKIS: Right, right.

23 MR. LANGMAN: You know, you prove from  
24 first principles that the code doesn't do anything  
25 that it shouldn't do. We're talking about safety

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1 analysis computer codes. So it is --

2 DR. APOSTOLAKIS: It's very different,  
3 right.

4 MR. RICHARDS: So the way that we maintain  
5 compliance with our procedures is we verify it through  
6 internal third party and regulatory audits.

7 DR. APOSTOLAKIS: Well, but why would it  
8 be different? If one method is very useful in one  
9 area, why isn't it in another? This is just a  
10 development of the code. It has nothing to do with  
11 what the code does. So I'm curious why in the safety  
12 critical area you do one thing and for thermal  
13 hydraulics you do something else.

14 Well, thermal hydraulics is, of course,  
15 easy. So it's not --

16 (Laughter.)

17 MR. LANGMAN: No, no, but I think our  
18 approach to verification and validation is very  
19 similar to that in the United States. For the safety  
20 critical software work --

21 DR. APOSTOLAKIS: I thought you were doing  
22 better than we were.

23 MR. LANGMAN: Well, maybe for safety  
24 critical software. It is an algebraic and very  
25 rigorous verification process that took for -- I was

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1 involved in it a bit way back when. I mean, it took  
2 probably 100 person-years to formally validate 3,000  
3 lines of code, and we generated piles of functional  
4 tables that proved, you know, from first principles  
5 that the code was perfect.

6 But, you know, applying that, I think  
7 system thermal hydraulic codes tend to be a little  
8 longer than 3,000 lines, too.

9 MR. SIEBER: Well, we have the same  
10 situation of V&V requirements under Reg. Guide 1.182  
11 are very stringent and require detailed methodology,  
12 but they apply to instrument and control codes,  
13 protection codes as opposed to design codes.

14 MR. RICHARDS: Yes, but what I'm talking  
15 mainly here is analytic, scientific and design  
16 computer programs. So programs we use in safety and  
17 licensing analysis where we have to.

18 MR. SIEBER: A lot of the validation there  
19 is based on test data.

20 MR. RICHARDS: Yes, which I'll be getting  
21 into in a little bit.

22 MR. SIEBER: Right.

23 MR. RICHARDS: Within Canada we have what  
24 we call industry standard tool set. I guess some five  
25 years ago we realized the formal qualification of

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1 safety and licensing code. We recognized that it  
2 would require significant investment, and if we could  
3 develop a standard tool set, it would result in you  
4 wouldn't have redundancies and inconsistencies if  
5 undertaken separately by each organization.

6 So the Canadian utilities and ACL worked  
7 together to qualify a standard set of computer codes.  
8 We all agreed to meet the common processes of our  
9 standard CSA N-286.7, and we agreed to share effort on  
10 code development qualification and support.

11 If we look at key ACR computer codes, I  
12 won't go through them all but essentially have  
13 physics, panel, containment, and fission product  
14 transport, and severe core damage.

15 So I'll be talking about validation  
16 methodology, and it applies to all of these codes, but  
17 what I will do is I will just use CATHENA as an  
18 example, which is our system thermal hydraulics code.

19 DR. APOSTOLAKIS: What does it stand for?

20 MR. RICHARDS: CATHENA is Canadian  
21 Algorithm for Thermal Hydraulic Analysis.

22 MR. SIEBER: Not related to Athena

23 MR. RICHARDS: Athena, no.

24 MR. RICHARDS: Pardon me?

25 DR. WALLIS: What's the E for?

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1 MR. RICHARDS: Thermal, t-h-e.

2 DR. WALLIS: Oh, that's the thermal part.  
3 Okay.

4 MR. RICHARDS: Yeah, we just chose the  
5 letters.

6 DR. WALLIS: So where does analysis start?

7 MR. RICHARDS: CATHENA, okay, code for  
8 thermal hydraulic analysis.

9 DR. WALLIS: This is a non-analysis, and  
10 that -- well, never mind.

11 (Laughter.)

12 MR. RICHARDS: Canadian algorithm for  
13 thermal hydraulic analysis. Canadian, C, algorithm,  
14 A, T-H-E, thermal, T-H-E-N, analysis.

15 DR. WALLIS: N is a bit -- well, never  
16 mind.

17 CHAIRMAN KRESS: What's in a name?

18 MR. RICHARDS: So the CATHENA model is a  
19 nonequilibrium model, six equation. You have two  
20 velocities, two temperatures, two pressures, and you  
21 can also include noncondensibles.

22 We have flow regime dependent,  
23 constitutive relations which couple with the two-phase  
24 model, and CATHENA can interface to other codes  
25 through PVM, like fuel behavior, plant control

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1 physics.

2 So one of the important things that the  
3 code has to be able to do is to predict the behavior  
4 in the CANDU channel, which could involve  
5 stratification of the code.

6 CATHENA has quite a detailed what we call  
7 solid heat transfer model.

8 DR. WALLIS: It's a one dimensional --  
9 excuse me -- it's just a one dimensional code  
10 presumably?

11 MR. RICHARDS: It is a one dimensional  
12 code, yeah, but when you look at the channel here,  
13 it's like pseudo two dimensional that you can infer a  
14 level in the stratified flow.

15 So the heat transfer model will identify  
16 if you are in the stratified flow where the level is  
17 and which pins would be above that level and which  
18 pins would be below that level, and that will  
19 determine the heat transfer.

20 So you could have multiple surfaces for  
21 thermal hydraulic code. You can model radial and  
22 circumferential conduction, and as I mentioned before,  
23 you have to consider stratified flow. When the --

24 DR. RANSOM: Does that stratification  
25 model consider that boiling may be occurring in the

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1 liquid collapsed layer so that you have some voids  
2 below the interface and perhaps even entrainment above  
3 the interface?

4 MR. RICHARDS: We do have a model, a level  
5 swell (phonetic) model that's not normally used.

6 DR. RANSOM: Not in a transverse direction  
7 though?

8 MR. RICHARDS: Yeah. No, the assumption  
9 right now is that the way the code is normally used is  
10 that the bottom layer is strictly liquid.

11 DR. WALLIS: Does it get into this  
12 stratified mode only during an accident or is it  
13 running in this mode?

14 MR. RICHARDS: No, no. When you're under  
15 normal operating conditions, the flow are some 20 to  
16 30 kilograms per second and you don't see  
17 stratified --

18 DR. WALLIS: You don't.

19 MR. RICHARDS: -- conditions. We have a  
20 number of test programs that demonstrated that.

21 MR. SIEBER: And you probably don't see a  
22 level either.

23 MR. RICHARDS: well, you wouldn't see a  
24 level, but you can always infer a level in that you  
25 can look at the thin temperatures.

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1 DR. RANSOM: Well, what sort of void is  
2 produced under normal operation? I thought that was  
3 relatively small.

4 MR. RICHARDS: It is small, and that would  
5 be in a mixed flow because of the flow rate. It would  
6 be high.

7 DR. ROSEN: So you don't really have a  
8 level in this tube during all operations.

9 MR. RICHARDS: This is strictly under --  
10 CATHENA is used for LOCA analysis mainly.

11 DR. WALLIS: Dissolution conditions or --

12 MR. RICHARDS: Under natural circulation.

13 DR. WALLIS: There's no question which way  
14 it wants to go and that sort of thing.

15 MR. RICHARDS: Yes. We can model the  
16 deformed geometry, the pressure tube. I'm talking now  
17 of the code is used quite extensively for the CANDU 6  
18 system, and in that you can get deformation of the  
19 pressure tube and calandria tube, and that can be  
20 modeled.

21 DR. RANSOM: Is that from swelling, you  
22 mean, that the --

23 MR. RICHARDS: During accident conditions  
24 where you have the pressure tube heating up and you  
25 still have pressure within the pressure tube. As I

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1 say, this is used mainly for existing CANDU analysis  
2 where you can have this type of thing happen.

3 Our validation methodology, we have what  
4 we call a technical basis document, and then the  
5 technical basis document relates the safety concerns  
6 to phenomena governing behavior during a phase of an  
7 accident, a given accident, and then we have  
8 validation matrices which relate phenomena to data  
9 sets. There are validation matrices for the various  
10 disciplines.

11 So this is code independent. For a given  
12 code you would generate a validation plan before you  
13 start any validation without code. You would then  
14 conduct a number of validation exercises, and you  
15 would summarize those in a validation manual, and I'll  
16 talk about thermal hydraulics as an example next.

17 DR. RANSOM: One thing I'm kind of  
18 interested in, the standard you talked about at first  
19 in terms of the code satisfying those, there are  
20 really two issues that come up. One is the code coded  
21 correctly in terms of it representing, you know, what  
22 the analysts presumed it to represent, and then the  
23 third one, of course, is whether that model fits data  
24 or can be assessed.

25 But is there anything done to assure

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1 correctness of the coding irrespective of the model  
2 that it represents?

3 MR. RICHARDS: The standard talks mostly  
4 about the development of software. It does say that  
5 the qualification or the validation will take place  
6 through validation process, and it doesn't say exactly  
7 how you would do it. It just says that you will  
8 validate your code. You'll make sure that it  
9 represents reality.

10 This right here is what we've developed  
11 within our industry, and it gives a more descriptive  
12 way of doing it.

13 DR. RANSOM: Are these all FORTRAN codes?

14 MR. RICHARDS: Yes, the largest majority.

15 DR. RANSOM: And they comply with some  
16 standard version I would guess.

17 MR. RICHARDS: Most are done with FORTRAN  
18 77, though we're moving somewhat to FORTRAN 90. They  
19 would adhere to that, to those coding requirements.

20 So once again, technical basis document,  
21 we're given accident category, that this document will  
22 identify the key safety concerns. The expected  
23 phenomena governing the behavior that evolves with  
24 time during identical phases of the accident. It  
25 establishes a technical relationship between the

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1 technical disciplines, the safety concerns associated  
2 with the phase of an accident governing physical  
3 phenomena, and the relevant validation matrices.

4 So just an example, thermal hydraulic  
5 example, early in the LOCA you would expect great  
6 discharge charge characteristics and critical flow to  
7 be a primary phenomenon. I think in your terminology  
8 it was a high ranking of importance phenomenon,  
9 whereas during ECC injection, you would have  
10 quench/rewet characteristics as becoming a primary  
11 phenomena or one of the high ranking importance.

12 Validation matrices, and I'll be talking  
13 about one in the next few slides. Identify and  
14 describe phenomena relevant to the discipline. Rank  
15 the phenomena according to their importance in the  
16 accident phases, and that's consistent with the PIRT-  
17 like process, and it identifies data sets and cross  
18 referenced phenomena, and I'll be talking about the  
19 type of data that you can use, separate effects  
20 experiments, integral and/or scaled experiments,  
21 analytical solutions for inter-code comparisons, and  
22 it would include CANDU-specific data and otherwise  
23 international.

24 So this is just a sample of the table  
25 where along here we have what are phenomena, and I've

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1 only given ten. Our thermal hydraulics validation  
2 matrix has 23. I was doing the first ten, and then  
3 across the top here, this is for an existing CANDU, by  
4 the way. It's not for the ACR. A validation matrix  
5 has been largely developed for the ACR system, but it  
6 hasn't been finalized yet.

7 So we have the thermal hydraulic  
8 phenomena. We have the accident scenarios, and then  
9 you identify the phenomena as either primary or of  
10 high importance, secondary importance, or having very  
11 little importance.

12 The second part of the validation matrix  
13 looks at the data sets and the phenomena can be  
14 validated. It's in the data sets.

15 DR. RANSOM: I didn't see counter current  
16 flow limiting on there, and I thought that was a very  
17 important phenomena.

18 MR. RICHARDS: Yes, it is. It occurs  
19 farther down in the list.

20 DR. RANSOM: Oh, really?

21 MR. RICHARDS: I've just given the first  
22 ten. I had to sort of compress this. There would  
23 have had to be two more slides to get it.

24 DR. RANSOM: I thought that was quite an  
25 important thing in the CANDU type reactor --

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1 MR. RICHARDS: Yes.

2 DR. RANSOM: -- because of these small  
3 tubes, you know, feeding.

4 MR. RICHARDS: But if I did go down for  
5 that, you would see for those, for each of these  
6 accident scenarios, you would see --

7 DR. RANSOM: It's judged to be even lesser  
8 importance.

9 MR. RICHARDS: These phenomena are not  
10 ranked in order of importance.

11 DR. RANSOM: Oh, okay.

12 MR. RICHARDS: Okay. I'll try to move  
13 along a little more quickly. For experimental  
14 database we use for validating our codes -- and I'm  
15 just talking about thermal hydraulics -- we'll make  
16 use of quite a bit of international data: Edwards,  
17 Marviken, Christensen, Tess, and quite a few others.  
18 So we have gone through the literature, and we will  
19 use what we can that is available internationally.

20 When we look at CANDU specific tests, we  
21 can subdivide it into small scale experiments,  
22 component experiments, integral experiments, and we do  
23 have some CANDU plant transients.

24 And I'll just note here that the majority  
25 of existing data supporting current CANDUs can be used

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1 for validation of the ACR.

2 Where we found gaps to exist, and it's  
3 mainly at higher pressures and temperatures of the  
4 ACR, new experiments have been completed and others  
5 have been planned which we'll carry out.

6 DR. WALLIS: Don't you have some special  
7 phenomena like natural circulation with multiple tubes  
8 that give rise to some interesting things that you  
9 don't get from this sort of background of data that's  
10 available? You have to do your own experiments.

11 MR. RICHARDS: Yes, we'll be getting to  
12 that. So if we look at CANDU specific experiments, we  
13 conducted quite a large number. Flooding is important  
14 in the feeder system downstream of an elbow in the  
15 feeder system. That's where the flooding will occur.  
16 So we've conducted experiments to characterize that.

17 We've done experiments characterizing  
18 pressure tube calandria to heat transfer experiments;  
19 horizontal tube rewetting/refilling experiments; and  
20 also pressure tube circumferential temperature  
21 distribution experiments.

22 DR. WALLIS: These are all sort of  
23 separate effects tests?

24 MR. RICHARDS: Yeah, we call them separate  
25 effects, small scale experiments, yeah. So you're

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1 just looking at one particular effect.

2 If you look at full scale experiments,  
3 component experiments, we have test facilities that  
4 can look at feeder refilling, channel stratification,  
5 header studies, pump characterization, and end  
6 fitting. There are specific facilities, and these are  
7 generally full scale. They're not full scaled.

8 This is an example of --

9 DR. WALLIS: They are not full scale in  
10 the number of feeders, for instance.

11 MR. RICHARDS: No, but for instance, we  
12 can look at this. This is the cold water injection  
13 test facility. It has a CANDU typical channel here.  
14 It has CANDU typical end fittings, and it has a feeder  
15 system that is representative of what you would see in  
16 an actual CANDU system.

17 So the inlet and outlet headers would be  
18 scaled, but in this you could look. You can devise  
19 experiments where you can void the channel and  
20 initiate refill and monitor the refill through the  
21 system.

22 DR. RANSOM: Is that part of the Penoloff  
23 (phonetic) facility?

24 MR. RICHARDS: No, this exists at Stern  
25 Laboratories in Hamilton. This is just an example of

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1 a component test, and all of these are full scale.  
2 All that you're missing is the interaction between the  
3 channels.

4 So then you go to RD-14M, which is an  
5 integral facility, and it has not as many channels as  
6 an actual CANDU, but it has ten channels. So this  
7 facility has full elevation changes between major  
8 components and full venue dimensions of a CANDU type  
9 system. It has reactor typical heat and mass transfer  
10 rates, ten full length electrically heated channels,  
11 a total of 11 megawatts. That's a fairly large  
12 facility.

13 It has simulation of all primary side  
14 components, end fittings, feeders, headers, and steam  
15 generators, and in it you can generate full pressure  
16 and temperature conditions. That's for current CANDUs  
17 and ACR.

18 And in here you do, in fact, see under  
19 natural circulation that you do get interaction  
20 between the headers, and you can study it in this  
21 facility.

22 DR. RANSOM: Now, is that the facility  
23 building, Penelon (phonetic).

24 MR. RICHARDS: White Shell, yes.

25 DR. RANSOM: Yeah, White Shell.

1 MR. RICHARDS: Just some example  
2 validations of CATHENA, the type of validation that we  
3 perform, and start with the Marviken test.  
4 Essentially you have the CATHENA calculated mass flow  
5 rate, measured mass flow rate, and these are your data  
6 points. So the discharge model does reasonably well  
7 in CATHENA.

8 And you go through a range of conditions,  
9 top blow-down steam, bottom blow-down water.

10 These are some experiments that we  
11 performed looking at the actual void in the RD-14M  
12 channel, and the only way we could get the void with  
13 the accuracy we wanted and the time resolution was to  
14 use a neutron scatterometer which we developed, which  
15 actually looks right through the channel.

16 And in it you can see the experiment and  
17 the CATHENA prediction.

18 DR. WALLIS: And you don't have enough  
19 flux or something to get good resolution, which is why  
20 it jumps around so much?

21 MR. RICHARDS: Yes. Yeah, and with gamma,  
22 if you use a gamma densitometer, the uncertainty would  
23 be --

24 DR. WALLIS: It's just the statistics of  
25 the radiation.

1 MR. RICHARDS: Yeah.

2 DR. WALLIS: So that the void fraction  
3 bigger than one is simply an artifact.

4 MR. RICHARDS: Or less than zero, yeah.  
5 It's within the air bounce.

6 DR. WALLIS: That's interesting. Usually  
7 it's the code that jumps all over the place, but in  
8 this case the code is very --

9 MR. RICHARDS: Well, no. It turns out if  
10 you look at it, the code is just looking at voiding,  
11 and essentially we have in the channel, we have 12  
12 nodes. So it would be over a .5 meter. So you  
13 wouldn't expect things to happen, voiding to happen  
14 that quickly. Other things, perhaps, condensation,  
15 but as for voiding, during this you have essentially  
16 blow-down. You'll have emptying of the channel,  
17 flashing. Those phenomena are not -- well, we see  
18 this as being smooth and with the other calculations.  
19 We get condensation with the deal.

20 DR. RANSOM: Data is from the RD-14?

21 MR. RICHARDS: RD-14M, yes.

22 This is a natural test in a CANDU 6 pump  
23 where they tripped one pump, and they looked at --  
24 they measured the run-down speed, and again, we can  
25 simulate that with CATHENA and get quite reasonable

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1 results.

2 So just in conclusion, we use a range of  
3 CODES in our ACR analysis, and they are developed and  
4 qualified under a formal SQA program. I've talked a  
5 little about the validation methodology. I've used  
6 thermal hydraulics and CATHENA as an example. The  
7 same is true for the other codes that I showed in an  
8 earlier slide, and we do have quite a bit of  
9 experimental information to use in our validation.

10 That's essentially it.

11 DR. WALLIS: There was a question of how  
12 much do you need in terms of data in order to answer  
13 the questions you're asking. It always seems to be a  
14 very judgmental thing.

15 MR. RICHARDS: At the end of the  
16 validation, our QA procedure says that the analyst  
17 should look at it and the analysts at least will say,  
18 "Are we getting most of these" or "was the validation  
19 successful or are there serious gaps?"

20 And if there are serious gaps, they're  
21 noted and we will try to look to other experiments.

22 DR. WALLIS: Ideally you'd like your data  
23 to tell you what the uncertainties are that you're  
24 going to put into something like that. A code, which  
25 eventually affects the PRA in some methodical way.

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1 You probably aren't that far along.

2 MR. RICHARDS: The validation, I believe  
3 you can use the validation of the code to get that  
4 uncertainty. For a lot of the validation, at least in  
5 the thermal hydraulics code, we do look at -- there is  
6 a portion of the validation that looks at uncertainty.  
7 We look at how does, for instance, if you alter the  
8 heat transfer coefficient within the range of its  
9 uncertainty, how does it affect this variable you're  
10 looking at.

11 So we are on our way towards it.

12 DR. WALLIS: Maybe at some time we'll have  
13 a smaller group of us look at that in some detail  
14 perhaps, if we get that far. A year or two?

15 CHAIRMAN KRESS: At this time, I'd like to  
16 note that we're so far behind that we've decided to  
17 postpone the discussion on the fuel design and the  
18 discussion on PRA methodology to some later meeting  
19 yet to be scheduled.

20 And at this time, before we get to the NRC  
21 staff presentation, which will be the next on the  
22 agenda, I would like to take about a 15 minute break.

23 DR. APOSTOLAKIS: Are we going to receive  
24 any documents of the actual PRA before we have that  
25 meeting?

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1 CHAIRMAN KRESS: I would like to have it  
2 before we have the meeting, yes.

3 DR. APOSTOLAKIS: Are there any plans for  
4 us to receive anything?

5 CHAIRMAN KRESS: There are slides in here  
6 on the overview of the PRA.

7 DR. APOSTOLAKIS: Yeah, I know, but it's  
8 just methodology, a high level discussion.

9 CHAIRMAN KRESS: Yeah.

10 MS. SOSA: Today you will hear from the  
11 NRC staff on PRA and what are the plans and process as  
12 for the pre-application review.

13 DR. APOSTOLAKIS: But you don't have it  
14 yet. You don't have the document.

15 MS. SOSA: I guess to answer that question  
16 I would refer to --

17 DR. APOSTOLAKIS: He said no already.

18 CHAIRMAN KRESS: But that would be a  
19 document we would want before that next scheduled  
20 meeting.

21 DR. APOSTOLAKIS: Sorry?

22 CHAIRMAN KRESS: We would want that  
23 document before that next scheduled meeting, George.  
24 So let's take a 15 minute break.

25 (Whereupon, the foregoing matter went off

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1 the record at 2:56 p.m. and went back on  
2 the record at 3:17 p.m.)

3 CHAIRMAN KRESS: I forgot we are also  
4 putting off the discussion on the negative void  
5 reactivity coefficient until a later time also.

6 So we're going to move at this time to the  
7 NRC staff presentation, and I'll ask Laura Dudes to  
8 introduce us to that.

9 MS. DUDES: Well, first I'd just like to  
10 say what a fantastic meeting this has been so far.  
11 I think we really appreciate the enthusiasm to which  
12 we have approached this topic. I think it's  
13 consistent with the Commission's advanced reactor  
14 policy statement and a lot of these questions, which  
15 I think they envisioned us engaging vendors early on  
16 these challenging issues and new technology.

17 As AECL has presented to us in one of  
18 their first slides, they may have over 50 years of  
19 operating R&D experience, but a lot of this technology  
20 is new to us, and so we're still in a heavy  
21 questioning mode.

22 The two project managers, Belkys Sosa and  
23 Jim Kim, are going to lead off this presentation, and  
24 then we also have several of our technical staff to  
25 speak with you this afternoon.

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1           As I said, AECL has about 50 years of R&D.  
2           The staff has had a few months. So they're going to  
3           be talking to you about their approach to their  
4           technical review, how they're going to try and ferret  
5           out regulatory and policy issues, and I'm not sure  
6           where we'll be in level of detail, but hopefully we  
7           can get some insights on what you think of our  
8           approach to the project.

9           Belkys.

10          DR. WALLIS: Could you give us any  
11          preliminary sort of insights or conclusions?

12          MS. DUDES: I don't think we're going to  
13          be at that level of detail today. However, from this  
14          meeting I know we'll all be together several occasions  
15          in the near future.

16          MR. SIEBER: Well, maybe we could ask a  
17          similar question. Are there some real hard spots that  
18          the staff is concerned about? If so, what are they?

19          MS. SOSA: Good afternoon. I'm Belkys  
20          Sosa.

21          DR. WALLIS: The other question is: have  
22          you done any real work yet?

23          (Laughter.)

24          MS. SOSA: Before I get to my  
25          presentation, I'd like to address a few comments. The

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1 pre-application review in general terms is a voluntary  
2 process. A lot of the issues, well, all of the issues  
3 really are raised by the applicant, and the staff,  
4 through the pre-application review so far, Phase 1,  
5 has been a familiarization phase, basically just  
6 coming up to speed, reading a lot of the material that  
7 has been submitted, attending meetings, developing  
8 RAIs, that sort of thing.

9 Phase 2, which is what we're currently in,  
10 it's really the beginning of the review process, and  
11 as we said many times today, pre-application is not  
12 going to close out or resolve the issues that we've  
13 seen today. These are not easy things. This is  
14 basically all of the difference that this design has  
15 in comparison to what we normally see in the --

16 DR. WALLIS: But you have developed RAIs?

17 MS. SOSA: They have developed RAIs in  
18 thermal hydraulics, in neutronics,

19 DR. WALLIS: Have they got any answers?

20 MS. SOSA: -- PRA.

21 You will hear from the staff on the  
22 issues, the key focus topics. So I would --

23 DR. WALLIS: So we will hear on that.

24 MS. SOSA: Yes.

25 DR. WALLIS: Okay.

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1 MS. SOSA: You will hear from the staff,  
2 and in some cases their review is more advanced than  
3 others. It depends on the issues. So please bear  
4 with us.

5 Today we're here for information mostly.  
6 We're not ready to present results or even speculate  
7 on what the issues are at this point. Everybody has  
8 ideas, but we're not there yet. So please bear with  
9 us. There will be other subcommittee meetings where  
10 we would get into a lot of the details, and I'm sure  
11 all of the important stuff will come up.

12 What I'd like to request from the  
13 committee is to give us feedback on our process and  
14 what the plan is for pre-application review, and also  
15 this is big picture. We don't want to forget the  
16 ultimate goal, which is the signed certification.  
17 Even though by September of this year, we will be  
18 developing what we call the safety assessment report,  
19 which is the deliverable that the NRC will be  
20 providing to AECL. This will include the  
21 identification of the technical issues that have been  
22 identified on this pre-application review, policy  
23 issues, regulatory issues, the schedule, and the  
24 resource estimates.

25 But, again, it will not bring to closure

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1 as far as a safety evaluation, but will simply be a  
2 snap picture in time, and hopefully will provide  
3 valuable feedback to the applicant. We believe so.

4 Well, let me go to my slides, and I won't  
5 go through all of them. I'll try to be brief. I  
6 think that you've heard a lot of these points already  
7 from AECL and others.

8 Because the ACR-700 is a unique design,  
9 there are unique features, and the approach and  
10 criteria to be applied in a design review is going to  
11 be different in some cases to that of conventional  
12 live water reactors. Their review will identify where  
13 new staff positions, regulations and regulatory  
14 guidance is needed to address the unique  
15 characteristics of the design.

16 For instance, pressure tubes --

17 DR. APOSTOLAKIS: What does that mean, new  
18 regulatory guidance? That may take a long time.

19 MS. SOSA: Well, we may find that out.  
20 It's not necessarily clear. Like I said, in a lot of  
21 these issues, for the key focus topics you will hear  
22 from the staff today on what their plan is.

23 DR. APOSTOLAKIS: So is it possible you  
24 will say we cannot certify this design because we need  
25 three new rules? I mean, I don't understand

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1 because that --

2 MS. SOSA: They have brainstormed on that  
3 issue, and in particular for the Class I pressure  
4 boundaries one of the most critical areas that we're  
5 looking at for this topic, and you will hear from them  
6 on the best approach that they have so far, and there  
7 are many ways to do it, but they figure out a way  
8 where we can do this relatively within the time frame  
9 that it will be the best solution, if you will.

10 So I would ask you to please wait until --

11 MR. FLACK: Yeah, excuse me, George. Part  
12 of the purpose of the pre-application review is to  
13 flesh out any policy issues ahead of time without  
14 waiting for the design certification process to take  
15 place. So a lot of it is to look at what's different  
16 with this plant and how we would go into the licensing  
17 design certification with this plant and then raise  
18 those up as policy issues if we see differences or  
19 discrepancies between the two.

20 So it's really a fundamental purpose of  
21 the pre-application review.

22 CHAIRMAN KRESS: Well, let me ask you a  
23 specific question about that. I gathered from what  
24 I've heard so far that their LOCA thermal hydraulic  
25 analysis is somewhat akin to Appendix K, but I would

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1 be surprised if they're using the Moody blow-down  
2 model, and I would be surprised if they're using the  
3 decay heat curve that we specify in Appendix K.

4 What will you do about things like that?

5 MS. SOSA: Well, today you will hear from  
6 Walt Jensen. He's the lead on the thermal hydraulics  
7 review, and if you like an answer now, I can ask him  
8 to get up.

9 CHAIRMAN KRESS: No, no, no.

10 MS. SOSA: You can wait. Thank you.

11 DR. APOSTOLAKIS: But we can ask the  
12 Canadians to pay for our changing our regulatory  
13 structure.

14 CHAIRMAN KRESS: That would be a good  
15 deal.

16 DR. APOSTOLAKIS: That would be a good  
17 deal.

18 (Laughter.)

19 CHAIRMAN KRESS: Maybe we could use their  
20 FC curves.

21 DR. WALLIS: But all of the presentations  
22 seem to be about things you're going to do, and that's  
23 so obvious. Read all documents and think about them.  
24 What are you going to tell us?

25 MS. SOSA: Well, (pause) --

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1 MS. DUDES: Part of the things and the  
2 reason why we're here today -- excuse me, Belkys -- is  
3 to tell you and to actually get to Minsites (phonetic)  
4 because as I think you see here, we're going to have  
5 regulatory infrastructure issues. We're going to have  
6 policy issues.

7 Part of the review is to identify them,  
8 develop a plan to get those to the Commission, and  
9 again, yeah, we may find in this pre-application  
10 review that we will need additional infrastructure,  
11 regulatory infrastructure, or policy decisions, and  
12 our plan here at the subcommittee is to present this  
13 approach and get insights for particular topics, if  
14 you have insights on which way we should be leaning  
15 and developing these policy or infrastructure needs.

16 MS. SOSA: Thanks, Laura.

17 In the application of exhibit regulation  
18 and guidelines, the staff may need to interpret  
19 guidance developed for live water reactors for  
20 application to non-live water reactor concepts.

21 CHAIRMAN KRESS: Now, you're doing this as  
22 a non-LWR?

23 MS. SOSA: No. I'm saying that there are  
24 certain areas that are not --

25 CHAIRMAN KRESS: Not applicable or can't

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1 do.

2 MS. SOSA: Exactly.

3 CHAIRMAN KRESS: But still it's an LWR.

4 MS. SOSA: Yes, sir. Thank you.

5 DR. WALLIS: Now, you way you have an  
6 equivalent level of safety. I thought that they were  
7 trying to get a higher level of safety in these  
8 advanced reactors.

9 MS. SOSA: Well, I would like to have --

10 DR. WALLIS: It's up to you to figure that  
11 out. It's your regulations.

12 MS. SOSA: Well, at this point it's --  
13 what I have on the slide is the equivalent level of  
14 safety.

15 CHAIRMAN KRESS: I gather from that that  
16 you meant when you look at their analysis of the  
17 design basis accidents, that they will have design  
18 basis accidents that are almost equivalent except for  
19 ones that can rule out, and that they will meet the  
20 regulations we have on the books now for those.

21 MS. SOSA: Yes.

22 DR. WALLIS: Yeah.

23 CHAIRMAN KRESS: That's the way I  
24 interpret that.

25 But the equivalent level of safety being

1 greater will be that maybe they'll have more margins,  
2 and maybe they'll have a PRA that shows that --

3 DR. APOSTOLAKIS: But they don't have to.  
4 The Commission has expressed a wish. They didn't  
5 issue a regulation.

6 CHAIRMAN KRESS: I think that's a pretty  
7 strong decision.

8 DR. APOSTOLAKIS: But they already claim  
9 that they have better core damage frequency and --

10 CHAIRMAN KRESS: Sure. I think they  
11 probably do. Okay.

12 MS. SOSA: Okay. What you have here is  
13 the focus topics that you heard about extensively this  
14 morning, and the underlined items are the key focus  
15 topics. As you see, I've added the fuel design  
16 separately already, which is what we've agreed so far.

17 And as far as the status, we've completed  
18 Phase 1. We're now in Phase 2, and this includes per  
19 panels, some thermal hydraulics of neutron accidents  
20 and neutronics, and you will hear a little bit of that  
21 today.

22 DR. APOSTOLAKIS: I'm a little confused as  
23 to what the difference is between pre-application and  
24 application. I mean, it seems you're doing everything  
25 that you would be doing.

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1 MS. SOSA: That's a good question.

2 DR. APOSTOLAKIS: You call it safety  
3 assessment report as opposed to safety evaluation  
4 report?

5 MS. SOSA: Yes. That's a good question,  
6 and that was also a result of a lot of discussions  
7 with the staff. In some areas it's not so simple.  
8 They don't have acceptance criteria that can readily  
9 apply. So they feel a little reluctant to use the  
10 same safety evaluation report as normally. So they  
11 felt comfortable with the safety assessment report.

12 In our mind it's a review, and it's the  
13 same type of review. It's not going to be anything  
14 different. In some areas as far as when we're done  
15 with pre-application, we will be a little farther in  
16 the process than in others, but we see it as something  
17 that can easily be transitioned to the design  
18 certification once the application comes in, and  
19 that's the plan.

20 Today we're hoping to hear, to get some  
21 feedback on what you think of the plan and the  
22 process.

23 CHAIRMAN KRESS: Well, to me, George, the  
24 pre-application gives the applicant a signpost that  
25 says, "How am I going to go any further than this?"

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1 and it's the place for him to make that decision. You  
2 know, if it were just in an application for  
3 certification, you wouldn't have to figure out when to  
4 do that. You could still do it. I think you can  
5 withdraw an application, but this gives them a point  
6 to stop and look at things and decide whether they're  
7 going forward with this.

8 MS. SOSA: I think it was a very smart  
9 decision of AECL to bring this pre-application forward  
10 when they did. It gives the staff an additional  
11 period to look at the issues and try to come up with  
12 a plan that would be useful, and also the main goal of  
13 pre-application is to facilitate the ultimate design  
14 certification review.

15 DR. APOSTOLAKIS: So that would be a good  
16 idea then for Gen-4 reactors, if they ever ask for  
17 certification.

18 DR. WALLIS: Your product is a safety  
19 analysis assessment report?

20 MS. SOSA: I'm sorry? What was the  
21 question?

22 DR. WALLIS: I'm just wondering what a  
23 safety assessment report is.

24 CHAIRMAN KRESS: That's the end point of  
25 Phase 2, right?

1 DR. APOSTOLAKIS: She's saying it's the  
2 same as SER.

3 MS. SOSA: Yes.

4 CHAIRMAN KRESS: It's not exactly an SER  
5 because they don't have to have an SER.

6 DR. WALLIS: That's the product of the  
7 pre-application review.

8 MS. SOSA: I have a slide here, and let me  
9 go to that, that it has the main sections of what the  
10 ultimate report is going to contain, and it's not  
11 consistent exactly with the safety evaluation report,  
12 but it's along the same lines. It's substantial, we  
13 feel, that this is what AECL really needs to have by  
14 the end of September in order to --

15 DR. WALLIS: Is AECL going to respond to  
16 their desired outcomes?

17 MS. SOSA: They stated in there these are  
18 outcomes; the word "acceptance" a lot, and we  
19 struggled with that, and we told them that we didn't  
20 think that we could accept and give them a definitive  
21 safety determination by the end of pre-application.  
22 That was not what we saw.

23 What we could give them is what we have  
24 here. Essentially as far as the material that the  
25 staff has been able to review and what has been

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1 submitted to date, that we could review that to the  
2 extent that the guidance exists, and we would identify  
3 technical issues that will require further data or  
4 analysis, as well as identify the regulatory issues,  
5 such as rules, rulemaking, or exemptions that will  
6 need to be resolved; policy issues; and hopefully in  
7 the conclusion we would give them a discussion on the  
8 feasibility of completing this review, as well as  
9 provide them with a schedule and resource estimates.

10 Now, the schedule and resource estimate  
11 would be to cover these focus topics, you know,  
12 essentially 12/13 items that you heard today. It  
13 won't be scheduling a resource estimate for the entire  
14 design certification. We will give them that estimate  
15 after we get a chance to review the application and  
16 see what it looks like.

17 There has been a lot of concern from the  
18 staff on, well, are they going to give it to us the  
19 way we are used to looking at it. So we hear from  
20 AECL, yes, you're going to get something that looks  
21 the same, the same type of format than what you're  
22 accustomed to. So we feel confident that that's what  
23 we'll get.

24 Now, Phase 2 of pre-application is  
25 scheduled to complete on September of this year. So

1 we have an aggressive schedule. This is an  
2 informational briefing. So please keep that in mind  
3 when you address the staff, and we'd love to get  
4 feedback today on what you think of our process and  
5 our plans.

6 And that's all I have.

7 Oh, I believe there was a question on QA  
8 that I'd like to address before --

9 DR. WALLIS: It would be useful if you had  
10 some milestones or something where you say what you  
11 want to achieve by the end of Phase 2 instead of the  
12 meetings you're going to have and what's the output of  
13 Phase 2? And what does it lead to? That would help  
14 me.

15 MS. SOSA: Yes. Kim, the other PM, will  
16 be addressing the schedule and highlighting some of  
17 the major milestones that's scheduled for the end of  
18 the presentation. So he will summarize that.

19 DR. WALLIS: Okay.

20 MS. SOSA: As far as the QA, I'd like to  
21 address the comment that was made earlier this  
22 morning. QA is an area where we feel very confident.  
23 In fact, we're actually doing more than what the  
24 applicant requested of us in their pre-application.

25 In some areas we're exceeding the scope of

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1 the pre-application, and we've told AECL this, and  
2 they seem to be okay with that, and we are working  
3 closely with our counterparts in the Canadian Nuclear  
4 Safety Commission, and they will be conducting audits  
5 in parallel, and there is a lot of work currently  
6 ongoing.

7 So we feel that that's one area where at  
8 the end of pre-application we will actually have more  
9 than what the applicant requested.

10 DR. APOSTOLAKIS: Will the staff request  
11 an ACRS letter at some point?

12 MR. SIEBER: Yes.

13 MS. SOSA: At some point, yes, but not for  
14 the pre-application.

15 CHAIRMAN KRESS: Usually what we do,  
16 usually, George, if we think there are showstoppers  
17 that are not forced in either the staff presentation  
18 or the things, we like to let them know that. It's  
19 not necessarily a letter. We can tell them verbally  
20 in the meetings, but sometimes we'll write a letter  
21 saying, "Here are some ACRS areas of concern and we'd  
22 like to hear more about." We'll do that sometimes.

23 But the real letter comes after we review  
24 the SER.

25 DR. APOSTOLAKIS: Which means when we

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1 actually are --

2 CHAIRMAN KRESS: That's the one that says  
3 we agree with the staff or we don't agree with the  
4 staff.

5 DR. APOSTOLAKIS: But we will not evaluate  
6 the safety assessment report because that's pre-  
7 application.

8 CHAIRMAN KRESS: Well, I think we can look  
9 at that, yes, and give them feedback.

10 MS. SOSA: We have plans to provide a  
11 draft safety assessment report in July and come back  
12 to you for a full committee in September, early  
13 September. So whether that requires a letter.

14 CHAIRMAN KRESS: It depends on whether we  
15 think everything is fine or whether we think there are  
16 problems. We could have a letter then.

17 MS. SOSA: Now, we are also working with  
18 your staff on arranging for subcommittee meetings on  
19 several areas. Probably materials will be one. PRA  
20 may be another. Thermal hydraulics. It's not clear  
21 exactly what your needs are going to be, but you will  
22 see more of this.

23 DR. FORD: So your hope is that if you're  
24 going to have an SER coming out in September, that  
25 before then, i.e., today you need us to flag to your

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1 prime stuff for doing these various sections, "Hey, I  
2 want to see more of this, this, this, and this in  
3 July."

4 Anything we're going to get in July, your  
5 draft report in July, I want you to cover these items.  
6 Is that correct?

7 MS. SOSA: If you feel that that's  
8 consistent with the approach for pre-application and,  
9 you know --

10 DR. ROSEN: Let me be sure I understand.  
11 Did you say you wanted subcommittee meetings with a  
12 PRA subcommittee, materials and metallurgy  
13 subcommittee?

14 MS. SOSA: That's what we're currently  
15 planning.

16 DR. ROSEN: With Human Factors  
17 Subcommittee perhaps? Who knows what all?

18 MS. SOSA: Committee meetings we can fit  
19 between now and July.

20 CHAIRMAN KRESS: We may combine some of  
21 those.

22 MS. SOSA: It's something that we need to  
23 do.

24 DR. ROSEN: But it's something that  
25 really, in fact, I think the suggestion is a good one.

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1 I mean, you're not going to get the level of detailed  
2 review that you need until you assemble those  
3 subcommittees and give them enough material to dig  
4 into.

5 MS. SOSA: Yes.

6 DR. ROSEN: And George's earlier comment  
7 about the PRA, yeah, well, the RPA subcommittee will  
8 do a thorough review if it has a PRA to look at. If  
9 it doesn't, well, it will just --

10 CHAIRMAN KRESS: Med and I are working out  
11 with Jim Lyons and the staff some sort of schedule for  
12 having meetings. You know, we're having things in  
13 mind like the next one might be a physics and fuel  
14 design, and then there might be a PRA combined with  
15 severe accident and almost surely be a thermal  
16 hydraulic subcommittee.

17 DR. ROSEN: Sure.

18 CHAIRMAN KRESS: And from there I'm not  
19 sure. There will be a materials maybe, but that might  
20 take five days or something.

21 DR. APOSTOLAKIS: But the rest of the  
22 committee has to agree on that.

23 CHAIRMAN KRESS: Yeah, but that's about  
24 the extent of it. You know, that's like four right  
25 there.

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1 MS. SOSA: Yes.

2 CHAIRMAN KRESS: That may be it. We'll  
3 have to review the SER. That's not coming out until  
4 next year some time.

5 MS. SOSA: No, no. This year.

6 CHAIRMAN KRESS: The SER?

7 MS. SOSA: This year. SAR.

8 CHAIRMAN KRESS: Oh, SAR we'll review.

9 DR. ROSEN: We're going to have to be done  
10 by July --

11 CHAIRMAN KRESS: We'll review the SAR.

12 DR. ROSEN: -- with all those  
13 subcommittees.

14 MS. SOSA: Yes.

15 DR. ROSEN: But give you the input you  
16 need, and that means we've got to get a lot of  
17 information through the subcommittee chairman and  
18 members of the subcommittees before then.

19 CHAIRMAN KRESS: We won't have that many  
20 subcommittees before July.

21 DR. ROSEN: It's very exciting, a very  
22 exciting time in which the ACRS will be devoting most  
23 of its attention to nothing but this.

24 DR. WALLIS: But we're not going to do all  
25 of the work. You guys have to come up with some

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1 results to us.

2 CHAIRMAN KRESS: Yeah, we can't have these  
3 meetings until they're ready for it.

4 MS. SOSA: That's right.

5 MR. FLACK: And this is John Flack again.

6 Just to add to that, it's also looking at  
7 our own infrastructure and what our needs are as well.  
8 So it goes in two places.

9 CHAIRMAN KRESS: Yes, right.

10 MS. SOSA: Thank you.

11 At this time I'd like to turn it over to  
12 Mr. Sullivan, and he will be addressing the first key  
13 focus topic. That's the Class I pressure boundary.

14 DR. ROSEN: Now, Ed, before you sit down,  
15 let me just tell you I looked ahead on your slides,  
16 and Slides 8 through 13 just repeat what we've already  
17 heard, but in your district. So why don't you skip to  
18 14 unless you think there's absolutely something  
19 that's burning that needs to be said in the interest  
20 of time. Fourteen is where you start talking about  
21 what the issues are.

22 MR. SULLIVAN: I would like to summarize  
23 what comes ahead of it though. I realize there's a  
24 lot of repetition, but --

25 DR. ROSEN: There's plenty of repetition.

1 MR. SULLIVAN: -- in our particular area,  
2 which may be different from some of the other reviews  
3 which I think you'll see this afternoon, what we feel  
4 that we need to do is see where this design, to the  
5 extent that we have information on it, does not meet  
6 our existing regulations.

7 What regs. do we know are going to need  
8 exemptions from or something like that, and what other  
9 areas are we going to need, as Belkys said,  
10 supplementary criteria, staff positions, requirements,  
11 whatever?

12 It's not going to be our intent in the  
13 pre-application review to try to resolve the issues.  
14 Our intent is to try to point out to AECL where we  
15 need additional information in their application, and  
16 to the extent we can, identify the kinds of things  
17 they asked for, namely, what might be a showstopper,  
18 that sort of thing.

19 So with that introduction, I'm probably  
20 going to not be very helpful in Slides 14 and 15  
21 because we're really not prepared to discuss them in  
22 any depth. These are just issues that, to the extent  
23 we've been able to familiarize ourselves with this  
24 design, they're things that we want to look into  
25 further.

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1                   And you can ask questions, but I'm not  
2                   sure we're going to be prepared to answer them. There  
3                   are several people in the room that have been  
4                   assisting in this review.

5                   DR. FORD: But if you look at the list of  
6                   comments on 14 and 15, all of the potential issues,  
7                   they're all absolutely bang on. You've hit the pin on  
8                   the head, but they all need numbers. We need, you  
9                   know, some data, some prediction algorithms, some  
10                  consequences, interactions, and that's all going to be  
11                  done by July.

12                  Is it going to be done by July?

13                  MR. SULLIVAN: No, it's not. it's not  
14                  possible. I'm not sure we even have enough  
15                  information to the review, and that's why I said a few  
16                  minutes ago that one of the things that we're going to  
17                  need to identify to AECL not just for pre-application,  
18                  but also for the application, is what additional  
19                  information we need to do the review.

20                  DR. APOSTOLAKIS: But I'm a little  
21                  confused though, Peter. I mean, there have been lots  
22                  of CANDUs around the world. There must be a lot of  
23                  data on these things and some arguments from AECL.  
24                  It's not that they are starting from scratch.

25                  So it could be done by July.

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1 MR. SULLIVAN: We don't have enough  
2 resources to do it by July.

3 DR. APOSTOLAKIS: Ah, that's different.

4 MR. SULLIVAN: And we don't have the  
5 information in hand, and we haven't communicated yet  
6 to AECL what additional information we need besides  
7 the main report which they have, which is the  
8 technology of the fuel channels.

9 DR. ROSEN: These are technical issues, by  
10 and large, but don't they have a border in some  
11 respects on policy issues and legal issues? And don't  
12 you have to bring in the OGC at some point?

13 MR. SULLIVAN: Yes, and that's one of the  
14 things that Belkys was communicating with the  
15 structure of the way the SAR is going to look. I  
16 think in our area we may be identifying safety issues  
17 that are also regulatory issues that may require  
18 policy direction.

19 DR. FORD: Forget the policy aspects for  
20 the time being, important though they are. For  
21 instance, some of the changes that the applicant had  
22 said they're going to make, thicker, thicker tubes,  
23 changing the alloy, these are all in the right  
24 direction, but it's qualitative. It doesn't tell you  
25 what is the factor of improvement going to be to

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1 counteract the bad effect of increasing the pressure  
2 and temperature, for instance.

3 I mean this is not a Nobel Prize winning  
4 exercise that has to be gone through. I mean, you  
5 don't have to do years of research. You've just got  
6 to look at the data and assess whether their case,  
7 qualitative case -- can you put a number on it, on the  
8 fact of improvement?

9 That's their job to do, to present to you.

10 MR. SULLIVAN: We also need to somehow  
11 develop acceptance criteria in order to evaluate this  
12 information. I grant you I think it must exist and  
13 some of it ACL is in the process of developing because  
14 I know that they're doing additional research in areas  
15 where they've had to extend the application for the  
16 ACR-700 design.

17 DR. FORD: So does it come down to the  
18 fact that you've got an agenda that by July of this  
19 year you've got to come out with a draft, but there's  
20 a whole lot of information you won't have; therefore,  
21 you're going to have to sign off in a state of un-  
22 knowledge, if that's the right word?

23 DR. APOSTOLAKIS: They're not signing off  
24 in July.

25 MR. SULLIVAN: We're not signing off.

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1 We're trying to identify issues. We're not really  
2 intending to resolve them. That's for the --

3 DR. APOSTOLAKIS: -- evaluation report.

4 MR. SULLIVAN: In other areas from the  
5 staff, I think you'll see some differences. In other  
6 areas the staff is getting into the review. They have  
7 the criteria they need to some extent or by and large.  
8 I'm not sure. They'll have to answer that, and their  
9 review is different from this one.

10 DR. ROSEN: And I would characterize what  
11 you'll be trying to do this year as a best efforts  
12 view, the best efforts to help AECL. If you come up  
13 with something else in November of this year that's  
14 not in your SAR, that's just the way it goes. It's  
15 not like there's any finality.

16 DR. FORD: So the way you are right this  
17 instant, January whatever it is, you're foreseeing  
18 that in July your report on these issues will be  
19 saying, "Hey, these are the issues."

20 DR. ROSEN: "That we see now."

21 DR. FORD: "This is where I want to be in  
22 a year's time," or whatever it is. "Mr. Licensee,  
23 please supply this data to me."

24 DR. APOSTOLAKIS: Plus certain issues have  
25 been resolved.

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1 DR. FORD: Oh, yes.

2 MR. SULLIVAN: We can also add in the  
3 meantime we're going to be trying to interact and  
4 provide information or documentation needs, and so  
5 forth. We're not going to wait until July or  
6 September if we can identify information needs before  
7 then.

8 DR. FORD: Sure, sure. Good.

9 DR. WALLIS: But if you don't start  
10 resolving some of these things, they're going to get  
11 pretty despondent. If all you do is keep asking for  
12 information and say these are issues without resolving  
13 anything, I would be pretty despondent as an applicant  
14 and say, "When is anything going to end?"

15 CHAIRMAN KRESS: I think our experience  
16 with the staff has been that when they do these  
17 things, if their intention is to resolve the issues,  
18 they'll get there depending on the resources.

19 DR. WALLIS: I would think you'd want to  
20 take one or two to see what kind of things come up.  
21 Then you'd all know more what kind of game you're  
22 playing.

23 CHAIRMAN KRESS: That might be a good  
24 suggestion.

25 MR. FLACK: Yeah, if I could just add to

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1 that, I mean, certainly it's important to do as much  
2 as we can on the pre-application review, but a lot of  
3 it is asking the right questions, and in order to ask  
4 the right questions, you have to probe and see what's  
5 out there, where the limits are.

6 And I think that is very important in the  
7 pre-application phase because that tells you how big  
8 the mountain is going be to climb, and the best way we  
9 can define that mountain, the better off we can be  
10 when we go into this.

11 So a lot of it is not to jump into trying  
12 to look at one issue in depth, but try to see how  
13 difficult all of these issues are and what are the  
14 most important ones to deal with as soon as we can.

15 So I don't want to underestimate that  
16 effort in trying to understand those issues and being  
17 able to ask the right questions.

18 MS. SOSA: So at this time I'd like to  
19 turn it over to Jack Rosenthal. He'll be presenting  
20 the PIRT process.

21 DR. APOSTOLAKIS: What qualifies you to --

22 CHAIRMAN KRESS: Yeah, do we know you?

23 MR. ROSENTHAL: My name is Jack Rosenthal.  
24 I'm the Branch Chief of the Safety Margins and Systems  
25 Analysis Branch, and I'm qualified as a supreme

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1 generalist, and they put me up here because I know an  
2 awful lot about a broad area and very little about any  
3 one. So we could have a reasonably fast presentation.

4 The researcher's job is to build tools  
5 that the regulator can use for independent analysis.  
6 So we are in the tool building business.

7 CHAIRMAN KRESS: Are we going to try to  
8 use space for this?

9 MR. ROSENTHAL: I'll get to that.

10 CHAIRMAN KRESS: Oh, okay. Sorry,

11 MR. ROSENTHAL: So we have to decide what  
12 numerical tools we could use, what data we have, what  
13 experimental facilities we have or might need in order  
14 to build validated tools.

15 I want to emphasize that this is a  
16 research program. Okay? We're not doing a design  
17 review of ACR-700 itself. That keeps coming up, but  
18 rather we're exploring ACR-700 to find out what we  
19 need to do to modify our codes in order to be able to  
20 do an independent analysis.

21 DR. APOSTOLAKIS: So you don't have to be  
22 done by July.

23 MR. ROSENTHAL: I don't have to be done.

24 DR. APOSTOLAKIS: Period.

25 MR. ROSENTHAL: We picked three areas, and

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1 I will explain why I think that these areas are  
2 important, neutronics, thermal hydraulics, and severe  
3 accidents, and as you see from the names, I think we  
4 really have a prestige group of people doing their  
5 work

6 DR. ROSEN: This is called Powers, Powers.

7 MR. ROSENTHAL: Dana Powers, your (pause)  
8 -- you recognize him.

9 CHAIRMAN KRESS: Is that a male or a  
10 female.

11 (Laughter.)

12 MR. ROSENTHAL: Here we're using the  
13 people that we think have the best knowledge to advise  
14 us independent of whether they have some involvement  
15 in the plan itself.

16 Bob Henry, for example, is a key developer  
17 of MAP, and the Canadians use MAP in their analysis,  
18 but I think that he is also a very knowledgeable guy,  
19 and we want to take advantage of that expertise.

20 DR. WALLIS: This has all just occurred.  
21 This is all --

22 MR. ROSENTHAL: All for the PIRT.

23 DR. WALLIS: And probably going to  
24 conclude that, therefore, AECL's PIRT is good.

25 MR. ROSENTHAL: Perhaps. BNL is the

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1 overall contractor. I'd like to say that the  
2 regulator, Canadian Nuclear Safety Commission, is  
3 participating in the PIRT, and we're learning from  
4 them; they're learning from us, and I welcome their  
5 involvement.

6 AECL has been very, very, very generous in  
7 supporting the PIRT, and I should publicly acknowledge  
8 that. They have provided a number of documents and  
9 have subjected themselves to the inquiring minds of  
10 people like Zuber.

11 (Laughter.)

12 MR. ROSENTHAL: In the PIRT process you  
13 need to -- let me stop with the thermal hydraulics for  
14 a second. NRC codes think vertical, and we have to  
15 teach our codes to think horizontal, and that's a  
16 major, major undertaking.

17 Walt Jensen is doing some analysis with  
18 CATHENA to familiarize himself with it. The Koreans  
19 have modified RELAP to look like a CANDU reactor, and  
20 we're building a RELAP deck for ACR-700, which we will  
21 give to NRR for their use. That will not address  
22 critical subchannel issues.

23 And then we will invest a little bit  
24 longer range in TRACE. Things like AP-600 have the  
25 advantage of the Apex facility as well as Rosa and

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1 other facilities. See, you have multiple, integral  
2 facilities at differing scales to benchmark your work.

3 Here much of the data comes from RD-14M.  
4 My staff has been up there. It is a very fine  
5 facility, but it's one facility. So we have to decide  
6 whether that data generated from that facility is  
7 adequate or would we need another facility, and that's  
8 big bucks and big time, and where would it be done and  
9 by whom, et cetera?

10 So that's why we decided to go with the  
11 PIRT process, to try to get some early advice on is  
12 the current database adequate. If additional data is  
13 needed, does it have to be done on a large scale  
14 integral or could it be done small scale?

15 AECL, I'm sure, would be more than willing  
16 to run some additional experiments at RD-14M. They've  
17 been very cooperative that way, but if something else  
18 is needed at a differing scale, maybe a smaller scale,  
19 maybe some university lab bench stuff to balance off  
20 the bigger scale stuff, but we've got to find out now.

21 Yes, sir.

22 DR. ROSEN: It could be one of those  
23 showstoppers.

24 MR. ROSENTHAL: Yes.

25 DR. ROSEN: This could be the showstopper.

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1 I mean, we haven't heard one yet today, but here's one  
2 that flops out like a big, ol' fish on the table. If  
3 you decide you need a whole other integral effects  
4 facility, not the money, but the item alone might be  
5 the showstopper.

6 MR. ROSENTHAL: Right, but so I think  
7 we've got the right people to advise us.

8 DR. ROSEN: All right.

9 MR. ROSENTHAL: Okay. They have to pick  
10 a break, and they pick this -- there is one critical  
11 break in which you get stagnant conditions in a flow  
12 channel, and so that may not be the riskiest break,  
13 but it's rich in -- and I don't know what the riskiest  
14 break is -- but it's rich in thermal hydraulic  
15 phenomena. So it's a good sequence to explore.

16 Of course, a figure of merit is fuel  
17 temperature versus time. As I say, we're going to  
18 have problems because we have to teach our thoughts,  
19 our databases, and our codes how to think horizontal.  
20 The PIRT process, you pick a sequence; you look at the  
21 systems and components; you rank stuff by importance.

22 And what we are asking for the PIRT panel  
23 to do is to identify high, medium and low, what's  
24 important and what's the knowledge base, high, medium,  
25 and low. A high-high is okay. It's very important.

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1 If I have a lot of knowledge about it, I can live with  
2 that.

3 A low-low is also okay. The showstoppers  
4 are a high-low, that is, where it's important  
5 phenomenologically, and the data, the knowledge base,  
6 the collective knowledge base is low. That knowledge  
7 base could be in the general literature. It could be  
8 for proprietary experiments. It doesn't have to be  
9 from another facility. We just need a sufficient  
10 amount of data.

11 So what we have to do by this spring is to  
12 identify if the experimental database is adequate, if  
13 the data is adequate. The writing of the computer  
14 codes if the data is there is far more tractable.

15 Okay. Let me just go on with the  
16 neutronics for a second. They're using codes like  
17 WIMS-8. We're familiar with the nuclear codes that  
18 the Canadians use, and that's just fine, although I  
19 don't think that Americans are familiar with  
20 dysprosium which is the burnable poison they use  
21 instead of gadolinium or something else. But that  
22 should be conceptually straightforward.

23 I mean, you know, how you go about doing  
24 calculations, getting cross-sections, et cetera, but  
25 what is super important, what I call in my mind, just

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1 my mind, a quintessential issue is, in fact, do they  
2 have a negative coolant void reactivity coefficient.

3 It's like 100 milli-K, some number like  
4 that, is the total void coefficient. So the number is  
5 very, very close to zero and is very difficult to  
6 measure it, but you'd like to have a negative number.

7 What we need to do, I don't need to have  
8 computed the number precisely by this spring, but I  
9 have to have enough exploratory work done that I have  
10 confidence that either the coefficient is, in fact,  
11 negative or could be made negative.

12 Now, just within, I'd say, the last six  
13 months to a year the designers have tweaked the  
14 enrichment and the burnable poison in order to give  
15 them a slightly more negative void reactivity  
16 coefficient for confidence, and you can always tweak  
17 these numbers again after all of this has taken place.

18 CHAIRMAN KRESS: Do we have a regulation?

19 MR. ROSENTHAL: But you have to be able to  
20 get there.

21 CHAIRMAN KRESS: Do we have a regulation  
22 on the book that says, "Thou shalt have a negative" --

23 MR. ROSENTHAL: I think we've got a GDC.

24 CHAIRMAN KRESS: A GDC says, "Thou shalt  
25 have a negative void coefficient"?

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1 MR. ROSENTHAL: Don? Go ahead.

2 MR. CARLSON: We have a general design  
3 criterion 11, and I can read that to you.

4 CHAIRMAN KRESS: Please.

5 MR. CARLSON: Basically it's often  
6 interpreted as calling for a negative power  
7 coefficient, but the exact words are, "GDC 11 reactor  
8 inherent protection. The reactor core and associated  
9 coolant systems shall be designed so that in the power  
10 operating range the net effect of the prompt inherent  
11 nuclear feedback characteristics tends to compensate  
12 for a rapid increase in reactivity."

13 MR. ROSENTHAL: Now, as I say, the codes  
14 that are being used here we're somewhat familiar with.  
15 They have done benchmarks. They're perfectly  
16 competent engineers, but here's a case where I think  
17 that it's a sufficiently important issue that we'd  
18 like to be able to do independent analysis and  
19 independently confirm the values.

20 And I think that of all things, I don't  
21 see this as a conceptually impossible problem. I  
22 mean, we know how to go about doing it. We've got the  
23 data; we've got the cross-sections; we've got the  
24 computer codes. It's a piece of work that we have to  
25 do, but I think that it's an important enough issue

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1 that we ought to be able to independently confirm that  
2 it's negative.

3 DR. WALLIS: It's all a paper subject,  
4 too. You're not going to build one and prove it. So  
5 eventually --

6 MR. ROSENTHAL: Well, we'd be relying here  
7 on things like criticals, benchmarks to criticals.

8 DR. WALLIS: Well, at all times you're  
9 going to rely on a paper study.

10 MR. ROSENTHAL: Well, here you've got  
11 benchmarks to criticals. Here you have separate  
12 effects and integral tests. So it's not totally paper  
13 at all. And severe accidents also has some  
14 experimental work.

15 Now, let me just talk about severe  
16 accidents for a minute. For some accident sequences,  
17 AECL says that, okay, what will happen is that you'll  
18 have a single channel that that could fail, and you'll  
19 quench, and you won't propagate, and that's the end of  
20 that event for that particular sequence.

21 That's very different from a U.S. light  
22 water reactor. We assume propagation TMI more than  
23 half the core melt (phonetic). So that's a very,  
24 very, very important issue, and if you can convince me  
25 that you'll never fail more than a channel worth of

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1 fuel, which is less than one percent of the fuel and  
2 you have a large dry containment, which they do have,  
3 then this is a very, very, very nice design.

4 So the focus then becomes on would the  
5 failure be a propagating failure. Similarly, if you  
6 have a whole core event, are you going to quench in  
7 the shield tank the event? You have a large dry  
8 containment, and the action is terminate in  
9 containment. Nice.

10 So the focus of me and the severe accident  
11 people is -- I keep pointing at the screen, and I know  
12 that doesn't do any good.

13 (Laughter.)

14 MR. ROSENTHAL: Just the super issue is do  
15 I have propagating failures or not because if I don't  
16 have propagating failures or if I can arrest the  
17 sequence in containment and it is the large dry  
18 containment, I think you're really in very good shape.

19 CHAIRMAN KRESS: Are steam explosions on  
20 the list for the severe accidents?

21 MR. ROSENTHAL: Only on the sense that  
22 what they're looking at is within the context of would  
23 you have a propagating failure, and in fact, if you're  
24 reliant on this hot molten stuff from a channel  
25 falling into the moderator as a way of terminating

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1 this, then the potential for steam explosion would  
2 truly be there.

3 CHAIRMAN KRESS: So that is on the table.

4 MR. ROSENTHAL: Yes. Now, in terms of  
5 fission products sought -- and so the focus here is  
6 more on accident progression, and we're going to have  
7 to teach Melcor how to do accident progression on this  
8 horizontal --

9 CHAIRMAN KRESS: You can't teach an old  
10 dog new tricks.

11 MR. ROSENTHAL: As distinct from --

12 CHAIRMAN KRESS: You don't have to worry  
13 about this candling down the fuel?

14 MR. ROSENTHAL: Don't have to worry about  
15 candling. Have to worry about quenching now.  
16 Different issues.

17 But in terms of source term, I see this as  
18 more of an action progression issue rather than a  
19 source term issue for two reasons. On one end, they  
20 have this big, nice containment, and the other thing  
21 is that things like the Canadians took actually a  
22 leadership role in an ISP, international standard  
23 problem, involving iodine, and so I think that they  
24 have some expertise in that area.

25 CHAIRMAN KRESS: Chemical effects or was

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1 that release from fuel?

2 MR. ROSENTHAL: It was chemical effects.

3 CHAIRMAN KRESS: They have a pretty low  
4 burn-out.

5 MR. ROSENTHAL: Yes.

6 CHAIRMAN KRESS: So that to me is a real  
7 plus.

8 MR. ROSENTHAL: A plus also. So at least  
9 conceptually in severe accident, within the severe  
10 accident real, my issues and I think the PIRT's issues  
11 involve accident propagation as the important issues.

12 CHAIRMAN KRESS: How much fuel is actually  
13 involved?

14 MR. ROSENTHAL: And if, in fact, it's --  
15 or for many of the sequences we're talking about a  
16 single channel or less. Then you really are in very  
17 good shape.

18 CHAIRMAN KRESS: I agree with you.

19 MR. ROSENTHAL: Now, they are going to --  
20 there is an experiment where they're going to -- I may  
21 need some help here -- they're going to put it's like  
22 100 kilograms of molten core in the water, and the  
23 initial experiments are actually being designed at  
24 Argonne and then the larger scale work will be done  
25 in --

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1 CHAIRMAN KRESS: That's like one channel.

2 MR. ROSENTHAL: Yeah. Am I getting the  
3 numbers all wrong? I have the numbers entirely wrong.  
4 I have the concept right and the numbers wrong.

5 MR. RICHARDS: So it's right. The  
6 formulation of the material that will melt is being  
7 done to Argonne.

8 MR. ROSENTHAL: And that's 25?

9 MR. RICHARDS: There will be first an  
10 experiment done at five kilograms, then 25.

11 MR. ROSENTHAL: Okay.

12 CHAIRMAN KRESS: Twenty-five is about one  
13 fuel change.

14 MR. ROSENTHAL: And then you're planning  
15 the larger test after Argonne is done?

16 MR. RICHARDS: Yes.

17 MR. ROSENTHAL: It will be how big?

18 MR. RICHARDS: The tested Argonne are done  
19 in a bursting a pressure tube into an air atmosphere.  
20 The experiments that are done at Chalk River will be  
21 looking at that material being injected into a  
22 calandria leak containment.

23 MR. ROSENTHAL: And that gets right to  
24 your issue.

25 CHAIRMAN KRESS: Well, the question I

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1 would have about that is how much of the zirconium are  
2 you going to have in that mixture. Does it melt and  
3 join in with the UO<sub>2</sub>? That would be the issue to me.

4 MR. ROSENTHAL: The experiments are it's  
5 a mix.

6 CHAIRMAN KRESS: Yeah, because I think  
7 that is a key element to determine the energy.

8 DR. WALLIS: Well, this study is new  
9 experiments; they haven't done them in the past? They  
10 don't have a database?

11 MR. ROSENTHAL: They've done some  
12 experiments. I'm now starting to run out of steam.  
13 So we'll stop. I mean, they've done some experiments,  
14 and there is some body of knowledge that pertains to  
15 this reactor also, but I think that the planned  
16 experiments will be crucial.

17 The plan is that we have had the second  
18 PIRT meeting already. We're going to have a third  
19 meeting, the physics guys in January and the thermal  
20 hydraulic guys and severe accident guys in February.  
21 We'd like to come out with some preliminary  
22 understanding in terms of the need for additional  
23 thermal hydraulic facilities in the March-April time  
24 frame based on our then understanding with a formal  
25 report in June.

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1 In parallel with that, I have a small  
2 effort going where co-developers are digging through  
3 subroutine by subroutine through code and not to  
4 modify the code, but just to figure out what has to be  
5 done because these are a rather large undertaking.

6 So that's where research stands.

7 CHAIRMAN KRESS: You had a slide that  
8 looked a little strange to me, and it said that --  
9 Slide 21 -- a large break of an inlet or an outlet  
10 header voids all fuel channels within one to three  
11 seconds. Is that true?

12 MR. ROSENTHAL: I believe so.

13 CHAIRMAN KRESS: Voids every pressure tube  
14 in one to three seconds.

15 DR. WALLIS: Gets dry?

16 MR. ROSENTHAL: No.

17 PARTICIPANT: "Void" it says.

18 DR. WALLIS: No, it's dry.

19 MR. ROSENTHAL: I need help again. David.  
20 There's Don Carlson standing behind you.

21 MR. CARLSON: Yeah, we're repeating what  
22 we heard from AECL in terms of the rate of voiding.  
23 A large complete break, double ended break of an inlet  
24 or outlet header we were told would void half of the  
25 channels, that is, the channels emptying into the

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1 affected header in about one second and drain the  
2 remaining channels in about one or two more seconds.  
3 A total of three seconds.

4 If AECL wants to elaborate on that or  
5 correct that, please speak up.

6 MR. SNELL: Victor Snell.

7 It sounds sort of half familiar. It will  
8 avoid the downstream channels, that is, half of the  
9 channels in the order of seconds. I think it takes  
10 much longer to void the opposite pass. That's my  
11 recollection.

12 MR. ROSENTHAL: Let's leave that up to  
13 the --

14 DR. WALLIS: Jack, thinking about  
15 interactions for the ACRS, particularly the thermal  
16 hydraulic subcommittee, presumably there's a good time  
17 for you guys and maybe the other guys, Jensen and  
18 company and whoever else is doing thermal hydraulics  
19 to meet with us. Would it be about the middle of the  
20 year or is that too late for you?

21 Maybe you'll let us know.

22 MR. ROSENTHAL: Yeah, I would think --  
23 Belkys, I'm looking you in the eye right now -- I  
24 would think about April we would have something to  
25 say. I mean, there's no sense --

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1 MS. SOSA: Between April and June is what  
2 we have on our milestones schedule, and again, the  
3 dates have not been set, but that's what we're aiming  
4 for.

5 MR. ROSENTHAL: Okay. Then I would think  
6 that, well, by May the PIRT panels will have met, have  
7 come up with their tables which we could present.

8 DR. WALLIS: I think when you have done  
9 enough work to know what the issues are and to know  
10 the scope of them rather than just that there are  
11 some, then it will be appropriate, but we don't want  
12 to meet you if you're going to tell us all about what  
13 you're going to do.

14 MS. SOSA: Yes, I agree with that. That's  
15 the plan.

16 DR. WALLIS: So let's work at that. Let's  
17 work at that.

18 DR. RANSOM: I'm curious. Wasn't the  
19 CANDU ever considered for licensing in the U.S.?

20 CHAIRMAN KRESS: They had a tentative  
21 thing that was withdrawn, I think, because --

22 MR. ROSENTHAL: It's my understanding it  
23 was withdrawn because of their reactivity coefficient,  
24 and --

25 CHAIRMAN KRESS: I think that was the

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1 showstopper.

2 MR. ROSENTHAL: --and here is a major  
3 difference. You're going from natural uranium to a  
4 big difference.

5 CHAIRMAN KRESS: And light water instead  
6 of heavy water.

7 MR. ROSENTHAL: Well, that heavy water,  
8 too

9 CHAIRMAN KRESS: Well, yeah, but light  
10 water in there where it matters.

11 MR. ROSENTHAL: Heavy water moderator.

12 CHAIRMAN KRESS: That makes a big  
13 difference in the void because it's more of a poison  
14 than it is a moderator.

15 MR. ROSENTHAL: Didn't we decide that  
16 something like 90 percent of the slowing down occurs  
17 in the moderator? That's one reason we have such a  
18 small void coefficient, is that the moderator which  
19 doesn't participate in the void can play such a large  
20 role.

21 MR. FLACK: Yeah, this is John Flack.

22 I believe it was looked under pre-  
23 application review. There was a policy issue on the  
24 positive void, but they had withdrawn before the  
25 Commission acted on that, and I think Don Carlson

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1 could add to that. I think that's probably --

2 MR. CARLSON: Yeah, about ten years ago  
3 for the pre-application review for the CANDU 3 design,  
4 at that time the staff highlighted the strongly  
5 positive coolant void reactivity of that design as a  
6 policy issue, brought it to the Commission, but  
7 shortly after AECL submitted the design certification  
8 application, they withdrew it for economic reasons,  
9 plus some uncertainty about that positive coolant void  
10 issue.

11 MR. ROSENTHAL: But now that you've gone  
12 to an enriched core, at least conceptually I think  
13 that there's some combination of enrichment level and  
14 burnable poison level that will give you a negative  
15 number, and in all likelihood they've done it right,  
16 and I think that it is something that we ought to be  
17 able to independently analyze.

18 MS. SOSA: I would like to turn it over to  
19 Mr. Jensen, and he will be going over the computer  
20 codes and validation focus.

21 MR. JENSEN: Good afternoon. I'm Walt  
22 Jensen, Reactor Systems Branch, and I see an up arrow  
23 and a down arrow, and I see a map.

24 (Laughter.)

25 MR. JENSEN: Let's see. Let's do a down

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1 arrow. Yes, here we are.

2 Unfortunately, I'm just going to talk  
3 about mostly what we're going to do because we've been  
4 doing a lot of review and done a little code analysis,  
5 but we're just getting started.

6 So the first slide is comparing what the  
7 AECL's desired outcome is to what I look on as our  
8 minimum objectives. So we're doing a review; we're  
9 looking for strengths and weaknesses. We are working  
10 on a list of REIs for the codes. We're looking for  
11 showstoppers; haven't found any showstoppers yet.

12 CHAIRMAN KRESS: Did they use the CSAU  
13 process in their code validation?

14 MR. JENSEN: It's similar. We're going to  
15 try to -- the PIRT process is part of that. I think  
16 it's not going to be a best estimate methodology, but  
17 it's going to be a limiting bounding methodology  
18 perhaps using Appendix K as much as they can. The  
19 part of Appendix K that certainly doesn't apply at all  
20 that I think was mentioned was the flooding rate  
21 guidance in Appendix K. If you've got less than one  
22 inch per second, you're supposed to do certain things  
23 and use of flat data, that just doesn't apply at all.

24 They have the Moody correlation within the  
25 CATHENA code.

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1 CHAIRMAN KRESS: Oh, they did put that in?

2 MR. JENSEN: It's in there. It's an  
3 option. There are many options in the CATHENA code,  
4 and we're asking for a methodology adopting that  
5 specifies exactly which options will be used for these  
6 Chapter 15 analysis that haven't been submitted yet.

7 Now, as far as --

8 CHAIRMAN KRESS: Do they have their own  
9 decay heat period?

10 MR. JENSEN: They have the --

11 CHAIRMAN KRESS: It's different than the  
12 ANS?

13 MR. JENSEN: They have the ANS 7 to 9  
14 standard. I'm not real sure about the 71 standard.  
15 They could put that under the table if they wanted to.  
16 They do have that capability. So I'm not really sure  
17 about that.

18 They have for the existing CANDUs. They  
19 run the CATHENA code in conjunction with the three  
20 dimension physics codes because it's really important  
21 to get the physics right for a LOCA because of the  
22 positive void coefficient.

23 Okay. So this is what we're trying to  
24 scope out what needs to be done, and besides that, we  
25 want to develop independent audit capability so we can

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1 run some of these same analyses that are important,  
2 and we can learn by looking at the results.

3 It's a lot more efficient to run the code  
4 ourselves and look at the results than ask them for  
5 that information.

6 DR. WALLIS: This would be running their  
7 code or running your codes or both?

8 MR. JENSEN: Both. I think we'll be  
9 running our code. I'd rather run our code because I  
10 understand it a lot better.

11 DR. WALLIS: Are they going to submit a  
12 working copy of the code so you can run their code?

13 MR. JENSEN: They have and we have. We  
14 have run their code. I hope not to run very many  
15 complex cases of the CATHENA code because I don't  
16 understand it. I've had about four days of hands on  
17 training with CATHENA, and I'm really a layman, but I  
18 have run what is called the critical inlet paddle  
19 break (phonetic), and I'm looking at that and we're --

20 DR. WALLIS: Give it to some young intern  
21 who will learn it in a day.

22 (Laughter.)

23 DR. RANSOM: Did they provide the source  
24 code to you?

25 MR. JENSEN: I don't have the source code.

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1 I just have an executable.

2 DR. RANSOM: I'm wondering if you would  
3 need that if you wanted to look at any specific -- I  
4 know that's a pretty big job, but --

5 MR. JENSEN: We may ask for that. I  
6 certainly wouldn't want to get in and try to change  
7 the code. I would be afraid I would screw it up.

8 All right. Let's see. Moving on, we do  
9 plan to use the guidance of the draft reg. guide.

10 DR. ROSEN: Do you still draft guides? I  
11 mean there have been drafts for six years or  
12 something. Are they still drafts?

13 MR. JENSEN: Well, this is a new version  
14 of the draft. I was told when I first did this slide  
15 I had the older version from the year 2000. It was  
16 Reg. Guide, I think, 1070 something, and I've updated  
17 it, put the current draft reg. guide, which we have,  
18 and it's good guidance, and I think industry has a  
19 difficult time with it, but we plan to use it.

20 We have the CATHENA theoretical manual.  
21 It's not for the current version of the code. There  
22 have been a few changes in it. So we want to find out  
23 about the latest code version.

24 DR. WALLIS: Does it look significantly  
25 different from the things you're familiar with, the

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1 other codes that vendors have or that you have? Isn't  
2 it much the same?

3 MR. JENSEN: Much the same except for as  
4 Jack mentioned, it's turned over on its side, and in  
5 addition to --

6 DR. WALLIS: There's nothing about the  
7 conservation laws or stuff that says anything about  
8 the orientation of the reactor.

9 MR. JENSEN: That's right.

10 DR. WALLIS: Basically the questions are  
11 all the same presumably.

12 CHAIRMAN KRESS: There's no gravity  
13 involved in neutron --

14 DR. WALLIS: You might consider a few more  
15 phenomena.

16 MR. JENSEN: Like the heat transfer from  
17 the fuel channel to the calandria tube, the swelling  
18 and creep of the fuel channel and how it made -- how  
19 it would come in contact with the calandria tube and  
20 then the transfer of heat out to the moderator tank,  
21 which is, I understand, an extra source of heat  
22 removal for the plant. I believe AECL feels that  
23 under certain conditions that the pressure tube would  
24 swell against the calandria tube and can remove all of  
25 the heat out of the fuel channel without causing

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1 additional overheating.

2 CHAIRMAN KRESS: What happens to those  
3 spacers then?

4 MR. JENSEN: That's a good question.  
5 There are four spacers, and there are springs  
6 separating the two tubes, and between the two spacers  
7 I suppose it could seal and make contact, but not the  
8 spacers. No, I don't suppose so. So that's something  
9 that we'll have to look at.

10 Resources. I'm getting a lot of help in  
11 this review for the CATHENA. We have the technical  
12 manuals and a number of presentations by AECL. We  
13 have the CATHENA executable and at an input deck.  
14 I've run it, am looking at the results.

15 We have a preliminary RELAP model. This  
16 is under a contract by the Office of Research, and we  
17 were given the RELAP input deck last Friday. I  
18 haven't run it yet.

19 I attend all of the PIRT panel meetings,  
20 and I'm getting a lot of valuable insight as they go  
21 over the phenomena that will be most important to  
22 analyzing LOCAs.

23 And then RES is helping us again with  
24 experimental facilities to decide whether the  
25 facilities are scaled correctly and if additional

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1 experimental data needs to be obtained, and they're  
2 going to provide that in the course of the preliminary  
3 review and perhaps hopefully by next spring.

4 Neutronics, well, this is being led by Dr.  
5 Tony Attard who is also in my branch, and he's  
6 following pretty much the same approach that I am with  
7 the CATHENA code. The main physics code is the RFSP  
8 code, which has been coupled with CATHENA for the  
9 operating CANDU plants to look at the power series  
10 where they carry out the LOCA, and that's the WINS and  
11 the DRAGON code that produce cross-sectional input to  
12 RFSP.

13 We may not need to couple physics and  
14 thermal hydraulics codes to the degree that they have  
15 been on for past CANDUs, operating CANDUs because of  
16 the positive model coefficient is no longer present.  
17 So we may be able to do a lot more with running RELAP  
18 by itself perhaps using point kinetics, but we have  
19 asked the Office of Research to develop a PARCS model  
20 that can be hooked into RELAP and then later into  
21 TRACE as the TRACE model is developed.

22 We also have a contractor at Brookhaven  
23 helping us review the physics equations in the three  
24 codes.

25 DR. WALLIS: It seems to me you might have

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1 a problem. This CATHENA code has probably had some  
2 tuning already to CANDU type reactors and horizontal  
3 flows and all of that. You have codes which are being  
4 developed for other purposes that have been tuned to  
5 other kinds of situations, and you may have a real  
6 problem with that depending on what kind of  
7 correlations to use or fudge factors or whatever.

8 MR. JENSEN: There has been some work with  
9 that. The South Koreans have given us some models to  
10 put into RELAP, which are in RELAP, that they've  
11 designed specifically to model the Korean CANDU 6  
12 reactor, and we have, in fact, -- there has been some  
13 benchmarking between RELAP and CATHENA for the ACR,  
14 and they seem to be doing pretty well.

15 The fuel channel model and RELAP does  
16 define a level. I'm not sure how good it is, but it  
17 defines a level so that the fuel pins that are above  
18 the level then overheat, and the fuel pins are lower  
19 than occurred, and let's see what else?

20 Other resources for both thermal  
21 hydraulics and neutronics, we're working with the  
22 CNSC. We're setting up for a protocol for aiding each  
23 other in our review. We have a thermal hydraulics  
24 meeting tomorrow afternoon that we're going to try to  
25 see how we can aid each other's review.

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1                   And of course, we have insights and  
2 guidance from the ACRS -- we will have -- which we  
3 always listen to. So then --

4                   DR. RANSOM: Walt, is the theory manual  
5 proprietary?

6                   MR. JENSEN: Yes, it is.

7                   DR. RANSOM: But I guess the ACRS could  
8 have a copy and look at it if they wanted to?

9                   MR. JENSEN: Yes.

10                  CHAIRMAN KRESS: As long as we treat it as  
11 proprietary.

12                  DR. RANSOM: It has quite a different  
13 numerical method and a somewhat different model, and  
14 it would be interesting to see what the latest really  
15 is.

16                  MR. JENSEN: I suppose, Belkys, could we  
17 get the ACRS?

18                  MS. SOSA: Yes, anything that we have  
19 available to us that's been docketed is certainly  
20 available for you. So I'll work with making  
21 arrangements.

22                  DR. WALLIS: Well, it sounds like a lot of  
23 work, and I just wonder what the minimum amount of  
24 work necessary is that might get you there by July.  
25 I don't have a good feel for it, but just hearing all

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1 of the things you guys want us to look at, it seems  
2 like a lot of work.

3 MR. JENSEN: Well, we're not going to be  
4 done by July.

5 DR. WALLIS: But you're going to write a  
6 report anyway.

7 (Laughter.)

8 MR. JENSEN: Well, yes, I guess it will be  
9 kind of -- the only reports I know how to write are  
10 SERs. I've written so many of those, and so it's  
11 going to look an awful lot like an SER, but there will  
12 be some places that probably say we have asked for  
13 more information here, and AECL has agreed to supply  
14 it.

15 We don't understand this. We need  
16 something else here, and at least it will document  
17 where the holes are, and then I suppose as we progress  
18 in the review perhaps several years, we'll slowly fill  
19 those holes in.

20 MS. SOSA: Thank you.

21 At this time I'd like to turn it over to  
22 Mr. Carlson, and he will be addressing the negative  
23 void reactivity review.

24 MR. CARLSON: I'm Don Carlson. I'm in the  
25 Office of Research in the Advanced Reactors Group. My

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1 work is technically in the area of nuclear analysis,  
2 but I'm also coordinating the overall research  
3 involvement in the pre-application review for ACR-700.

4 I'm going to ask the committee members to  
5 look at the handout package for AECL. My talk really  
6 assumed that we would go through AECL's talk on the  
7 coolant void reactivity first. The way I would like  
8 to do my talk is just to refer back to a couple of key  
9 slides from the AECL presentation to help you  
10 understand what I'm talking about in my slides.

11 So that's the yellow tab, negative coolant  
12 void reactivity in the AECL handouts.

13 So this work is in response to AECL focus  
14 topic number nine, confirmation of negative void  
15 reactivity. AECL's desired outcome is staff  
16 confirmation, or their word is "acceptance," that the  
17 coolant void reactivity is negative over a range of  
18 operating conditions.

19 Regulatory context of that is as came up  
20 during Jack Rosenthal's talk, is the void reactivity  
21 is key to evaluating the design in relation to general  
22 design criterion 11, reactor inherent protection.

23 The aim, as stated by AECL, is to have a  
24 negative coolant void reactivity so that it satisfies  
25 that requirement, GDC 11.

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1                   Furthermore, whether the void reactivity  
2                   is positive or negative, it can have a significant  
3                   impact on the progression of analyzed transience and  
4                   accidents.

5                   Now, before I get into my own slide, I'd  
6                   like you to look at the third slide of AECL's  
7                   presentation. That introduces you to how they go  
8                   about changing the design. This is the first CANDU  
9                   design that tries to have a negative coolant void  
10                  reactivity, and so that slide shows the top figure,  
11                  natural uranium, a conventional CANDU lattice with a  
12                  pitch of 28.6 centimeters center to center between  
13                  fuel channels, and a ratio of 16.4.

14                  In their new design, the ACR-700 that we  
15                  are reviewing in the pre-application phase, the  
16                  lattice pitch has been reduced to 22 centimeters  
17                  center to center, giving a greatly reduced moderator  
18                  to fuel ratio of 7.1.

19                  In addition to reducing the pitch, they  
20                  have also increased the diameter of the calandria  
21                  tube. That is they have increased the gap between the  
22                  pressure tube and the calandria tube. All of that  
23                  helps reduce the amount of heavy water moderator in  
24                  the lattice and gives them a more compact core in the  
25                  process.

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1 DR. WALLIS: Doesn't it matter where the  
2 void is?

3 MR. CARLSON: The void is in the coolant,  
4 which is --

5 DR. WALLIS: Yeah, but where in the  
6 coolant?

7 MR. CARLSON: The coolant is next to the  
8 fuel pins.

9 DR. WALLIS: But is it at the end or in  
10 the middle or is it a subcooled void or what kind of  
11 a void is it? Doesn't it make a difference? It's not  
12 as if this void is everywhere at the same time.

13 MR. CARLSON: Actually in CANDU analysis,  
14 and this was true for CANDU 3 ten years ago and is  
15 true in the way CANDUs are analyzed around the world,  
16 they talk about coolant void reactivity, which is the  
17 difference between effective voided and cooled. So  
18 voided, I mean all of the coolant is gone.

19 DR. WALLIS: It's all completely void.

20 MR. CARLSON: Yes.

21 DR. WALLIS: Okay. That I understand.  
22 Okay. Then I don't have to worry about where the void  
23 is. It's everywhere.

24 MR. CARLSON: Now, there's a void  
25 coefficient that you can derive from that, and it's

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1 not a straight line, but they often talk about coolant  
2 void reactivity as a way of focusing on what that  
3 coefficient is.

4 And during Jack's talk, i think he  
5 misstated, and I think during the AECL talks they did  
6 mention that the nominal coolant void reactivity for  
7 the equilibrium core as it is presently designed is  
8 minus seven milli-K.

9 DR. WALLIS: That's when all of the  
10 coolant has gone.

11 MR. CARLSON: That's right. So the  
12 difference between K effective, operating conditions  
13 cooled and voided is seven milli-K.

14 DR. RANSOM: Well, would this be  
15 demonstrated with a code by maybe forcing a void  
16 initially and seeing if it dies away, you know, if the  
17 power decreases?

18 MR. CARLSON: Are you talking about in a  
19 reactor?

20 DR. RANSOM: Well, in like CATHENA or  
21 CATHENA coupled with a neutronics code. You perturb  
22 it more or less like voiding a channel and then  
23 proving that it decays away.

24 MR. CARLSON: Well, they do calculations  
25 and we will be doing calculations and have started

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1 doing some calculations to predict what the coolant  
2 void reactivity is, and their code is RFSP, their  
3 reactor code, and that is coupled to CATHENA. If we  
4 move forward, we would couple our PARCS code with  
5 TRACE and/or RELAP, but the PARCS code needs to  
6 predict accurately what the negative void reactivity  
7 is, assuming that it is negative.

8 MR. SIEBER: I take it the idea to have a  
9 negative void coefficient is to design the core so  
10 that it is under moderated.

11 MR. CARLSON: Yes.

12 MR. SIEBER: During normal operation so  
13 that the void formation further exacerbates the under  
14 moderation, which provides a slowing down.

15 MR. CARLSON: Yes. The applicant has  
16 stated that with the current lattice that it is under  
17 moderated with respect to the light water coolant.

18 MR. SIEBER: And with regard to  
19 temperature coefficient, it's the combination of  
20 enrichment and poisoning that will change that  
21 coefficient.

22 MR. CARLSON: As AECL would point out, the  
23 magnitude of the coolant void reactivity is very  
24 sensitive to the fuel design.

25 MR. SIEBER: That's right.

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1 MR. CARLSON: And the fuel design that  
2 they are presently using -- and this changed during  
3 Phase I of the pre-application review -- during the  
4 beginning of Phase I the fuel enrichment was 2.0  
5 percent, and it had, I think, 4.8 weight percent  
6 dysprosium in the center pin, and in about June of  
7 last year, June 2003, they changed that to 2.1 weight  
8 percent and 7.5 weight percent dysprosium.

9 MR. SIEBER: And that should make a  
10 pretty --

11 MR. CARLSON: Well, it went from minus  
12 five milli-K to minus seven milli-K.

13 MR. SIEBER: Okay.

14 MR. CARLSON: And that was in part, I  
15 think, a reaction to our Phase 1 discussions where  
16 they felt that they needed to make it more negative to  
17 increase confidence that it is, in fact, negative.

18 MR. SIEBER: Because, too, that you're  
19 basically wasting neutrons.

20 MR. CARLSON: I think their nominal  
21 average burn-up went from 20 gigawatt days per ton to  
22 21.

23 MR. SIEBER: Okay. Well, you get some of  
24 it back.

25 MR. CARLSON: And so in Jack's talk he

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1 said that we understand that it can be made negative.  
2 If we don't agree that the present design is fairly  
3 negative with confidence under all operating  
4 conditions, they can further modify the fuel to make  
5 it more negative.

6 MR. SIEBER: Well, it seems to me that  
7 that's a fact, that with enough design changes, and  
8 some of them are pretty subtle because it's just  
9 enrichment and burnable poison strength, that you can  
10 make it have whatever characters that you want.

11 The question is: can you calculate it  
12 accurately enough to feel confident that you're really  
13 negative.

14 CHAIRMAN KRESS: Yeah, that's the third  
15 yellow sub-bullet on there, which I think is a very  
16 interesting question.

17 MR. CARLSON: Well, before I go into that  
18 slide, I wanted you to take a quick look at slide  
19 number nine. That's on the third page of the ACL  
20 presentations in the upper left-hand corner. It's a  
21 table of major contributors to the coolant void  
22 reactivity, milli-K in ACR, and there are two read  
23 numbers, which are the positive contributions to  
24 negative void reactivity, and a series of green  
25 numbers, which are the negative contributions to

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1 coolant void reactivity, as calculated by AECL.

2 DR. WALLIS: So you need your plutonium.

3 MR. CARLSON: Yes. It becomes more  
4 negative with burn-up, with the buildup of plutonium  
5 and the depletion of the positive effect of U-235.

6 DR. WALLIS: If you enrich it more, it  
7 makes it worse. Do you get more 235?

8 DR. RANSOM: No.

9 MR. CARLSON: Well, you need more  
10 dysprosium to balance out the effect of enrichment,  
11 and that's --

12 DR. WALLIS: It just about balanced,  
13 right?

14 MR. SIEBER: Yeah.

15 DR. RANSOM: Does this balance mid-life or  
16 end of life type imbalance?

17 MR. CARLSON: Peter chan can correct me,  
18 but I think it's based on a simple lattice calculation  
19 with the WIMS code for mid-burn-up fuel, mid-cycle  
20 burn-up fuel, and to that they've added a reactor  
21 leakage. So these are not firm numbers, but they're  
22 illustrative numbers.

23 MR. SIEBER: Well, these change constantly  
24 throughout the cycle, whatever you call a cycle.

25 MR. CARLSON: Well, they don't have a

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1 cycle. They have an equilibrium core.

2 MR. SIEBER: Right.

3 MR. CARLSON: And our review at this point  
4 is focusing exclusively on the equilibrium core  
5 because the initial and transitional cores have not  
6 been designed yet.

7 MR. SIEBER: Okay, but the challenge may  
8 be greater for the initial core. It could be.

9 MR. CARLSON: Yeah. It's an interesting  
10 question.

11 DR. ROSEN: Well, because you're not in  
12 plutonium.

13 MR. SIEBER: Well, on the other hand, you  
14 can choose the parameter levels, the constituent  
15 levels to force it even in the initial core.

16 MR. CARLSON: Yes, that's what AECL has  
17 told us. They're confident that they can --

18 MR. SIEBER: I believe that.

19 MR. CARLSON: -- they can tune it to what  
20 it needs to be in the initial and transitional cores,  
21 but we haven't seen exactly how they're going to do  
22 that.

23 DR. WALLIS: The bit red term is this  
24 hydrogen, the water.

25 MR. CARLSON: Yes.

1 DR. WALLIS: If you blow the water out, it  
2 becomes much more reactive.

3 MR. CARLSON: I'd like to point out  
4 because this is a common misconception, and I've heard  
5 from numerous sources, people who are new to this  
6 design say, "Oh, they've gone to light water cooling."  
7 Well, our light water reactors have negative power  
8 coefficients and negative moderator temperature  
9 coefficients.

10 MR. SIEBER: And that's because the  
11 enrichment is way up there.

12 MR. CARLSON: But, in fact, going to light  
13 water did not help AECL -- and they'll confirm this --  
14 does not help. In fact, it would be easier to make  
15 the coolant void reactivity negative if they had  
16 stayed with heavy water cooling.

17 MR. SIEBER: That's right.

18 MR. CARLSON: And the big effect there, as  
19 you see, is that 31.5 read number for loss of  
20 absorption by light hydrogen in light water.

21 DR. RANSOM: DY is deuterium, I guess?

22 MR. CARLSON: No, EY is dysprosium with  
23 the burnable poison.

24 DR. WALLIS: That's the one that cancels  
25 out the 235.

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1 DR. RANSOM: What is the effect of the  
2 calandria

3 MR. CARLSON: Well, it's zirconium. So  
4 the neutronic -- it's pretty transparent to neutrons.

5 MR. SIEBER: It's invisible.

6 MR. CARLSON: But we're discussing that in  
7 our PIRT discussions, and I'll be flying to Brookhaven  
8 tomorrow morning, as Jack indicated, to have the third  
9 PIRT meeting for neutronics.

10 MR. SIEBER: So the real issue is not can  
11 you calculate it and have enough confidence that you  
12 know that you got a reasonably good answer.

13 MR. CARLSON: Exactly. So let me go  
14 through my slide here.

15 AECL's nominal value of the coolant void  
16 reactivity is only slightly negative, that is, an  
17 informal definition of coolant void is  $K$ , that is, the  
18 neutron multiplication factor voided. Minus  $K$  cooled  
19 is minus .007 or minus seven milli- $K$ . A more formal  
20 definition is one over  $K$  cooled minus one over  $K$   
21 voided. Numerically they're the same when the cooled  
22  $K$  effective if one.

23 Anyway, it's only slightly negative. The  
24 coolant void reactivity is also a combination as we  
25 saw in that table from the AECL of large positive and

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1 large negative and small negative effects, and it is  
2 sensitive to core design. As I just said, slightly  
3 changing the enrichment and increasing the burnable  
4 poison, changed it from minus five to minus seven  
5 milli-K, and it's also somewhat sensitive to operating  
6 parameters. If there is a poison in the moderator,  
7 which they don't usually have but would have in the  
8 unusual case of restarting after long shutdown, they  
9 would have a small amount of boron in the monitor.  
10 That makes the coolant void reactivity less negative.

11 Another key observation is because of  
12 these factors, the evaluation of bias and uncertainty  
13 in the calculated CVR predictions, i.e., validation,  
14 will figure quite prominently in the staff conclusion  
15 and also how we model it. But validation of our  
16 models is key.

17 Interesting to note is that there will be  
18 no in reactor measurements of coolant void reactivity.  
19 They are difficult to do and they are not planned by  
20 AECL. That kind of measurement would basically call  
21 -- the straight measurement would call for you to have  
22 an operating or plant that's ready to operate and take  
23 out all of the coolant.

24 MR. SIEBER: Yeah, they just melt it.

25 MR. CARLSON: So there would be some

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1 reluctance and difficulty in doing that.

2 This is not to say that we're closing the  
3 door on any way of doing in reactor measurements, but  
4 we do acknowledge that it's difficult and there's no  
5 obvious way to do it, and it is not planned by AECL a  
6 this time.

7 DR. WALLIS: No one will ever know.

8 MR. CARLSON: So, therefore, we're stuck  
9 with what we predict, and those prediction methods  
10 will be validated based on some ACR specific benchmark  
11 measurements in the ZED-2 facility at Chalk River Lab.  
12 It's an AECL facility. We've been there, and we've  
13 seen it.

14 DR. RANSOM: Is that at zero power?

15 MR. CARLSON: This is a zero power  
16 critical facility.

17 CHAIRMAN KRESS: That's an interesting  
18 bullet about how confident are you.

19 MR. CARLSON: So the validation question  
20 becomes --

21 CHAIRMAN KRESS: A more interesting  
22 question to me is how confident do you have to be.

23 MR. CARLSON: Well, yeah.

24 CHAIRMAN KRESS: Is that a policy issue?

25 MR. CARLSON: Potentially, potentially.

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1 So, yeah, the question is when code calculations  
2 predicate a small negative CDR, how confident are we  
3 that the actual CDR will, indeed, be negative in view  
4 of prediction bias and uncertainty? Again, as  
5 determined by benchmarking against some semi-  
6 prototypic experiments.

7 Now, the experiments that AECL has done  
8 for validating the neutronic predictions for  
9 conventional CANDUs really don't help us here. They  
10 really have to do a set of ACR specific benchmarks  
11 because the neutronic phenomenology in this design is  
12 quite different from that in conventional CANDUs.

13 They have started doing some of those  
14 tests, and the majority of them will be finished in  
15 the next year or so. They're planning to complete  
16 them in 2005.

17 So as I alluded to a moment ago, a  
18 significant result from a Phase 2 pre-application  
19 activities was that in June 2003, AECL did change the  
20 fuel designed to make the coolant void reactivity more  
21 negative.

22 Some of the pre-application interactions  
23 we've had on coolant void reactivity, we've had some  
24 technical exchanges on coolant void reactivity  
25 analysis and validation, including facility tours of

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1 the ZED-2 facility, and in Vince Langman's earlier  
2 slide he said those were in December of '03. They  
3 were actually in December of '02, over a year ago now.

4 We developed a set of RAIs in March of  
5 last year, and AECL responses were provided and  
6 supporting document in June of last year, and in  
7 November and another set just came in last month, and  
8 there's more information coming as they solidify their  
9 program description and actually conduct their  
10 experiments.

11 We received our first information,  
12 detailed information, about the physics design of the  
13 core in that June response, but they immediately  
14 changed their design. So we have yet to receive that  
15 level of detailed information about the current  
16 design.

17 I provided established report in September  
18 of last year to Research -- well, I'm in Research --  
19 to NRR, and NRR forwarded that to AECL in September.  
20 We started our NRC PIRT activities in September and  
21 had our first meeting in October, our second meeting  
22 in December, and our third neutronics PIRT meeting  
23 later this week.

24 AECL has been very helpful with the  
25 presentations that they've made at those meetings and

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1 with the follow-up information that they were  
2 requested by the panel members during the meetings.

3 We've also had helpful participation by  
4 the CNSC staff as observers in those PIRT meetings.  
5 The CNSC, the Canadian regulatory staff, has also been  
6 making progress on their own in trying to do  
7 independent calculations of coolant void reactivity  
8 and we'll be hearing about that from them soon.

9 DR. WALLIS: What is the typical  
10 uncertainty in these calculations? When I went to the  
11 university a long time ago, the uncertainties were  
12 fairly high in these CVR calculations. Are they now  
13 narrowed to the point where when you say 15.1 you're  
14 pretty sure it isn't 13?

15 MR. CARLSON: That's a very good question,  
16 and I don't think it's quite that good, but we'll see.  
17 We're going to --

18 DR. WALLIS: You don't know?

19 MR. CARLSON: We're in the learning stage.

20 DR. WALLIS: You must know what's typical.  
21 Say what the odd is now. What's the sort of typical  
22 uncertainty in these numbers? Does anyone have a  
23 handle on that?

24 MR. CARLSON: Well, frankly, I'm not  
25 involved in light water reactor analysis.

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1 DR. WALLIS: But somebody is.

2 MR. CARLSON: But yet we do have people in  
3 NRR and in Research who are. So if anybody wants to  
4 speak up. My feeling is that ten to 20 percent --

5 DR. WALLIS: That's much too much.

6 MR. CARLSON: -- uncertainty --

7 DR. WALLIS: That's much too much to be  
8 sure with minus seven and these big numbers.

9 MR. CARLSON: For the moderator  
10 temperature coefficient. Uncertainties on that, in  
11 that general order of magnitude, somebody can correct  
12 me if I'm wrong.

13 DR. WALLIS: Not hearing a correction, we  
14 take it that each one number 31.5 is within --

15 MR. CARLSON: Oh, you're looking at that  
16 table? I would say, yeah, we have an uncertainty  
17 associated with plutonium. I don't know exactly what  
18 it is, but obviously we can't predict with absolute  
19 accuracy what the inventory of plutonium is as a  
20 function of irradiation.

21 And on top of that, we don't know with  
22 absolute accuracy what the effect of it, given the  
23 amount of plutonium in the fuel is on coolant void.  
24 The ZED-2 experimental benchmarks will give us a  
25 handle on that. Otherwise our analysis tools are

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1 pretty good, but just how good remains to be  
2 demonstrated in this context.

3 DR. WALLIS: So you don't have a feel for  
4 how good they are now? I would think you could look  
5 at somebody with an expert eye who knows these things  
6 and makes these calculations, could look at these  
7 numbers and say, "Gee, whiz, I'm not particularly  
8 confident," or, "I'm really sure that they're pretty  
9 close to minus seven because I know you can do these  
10 things accurately."

11 MR. CARLSON: We've been having these  
12 discussions in the context of the PIRT in the first  
13 two meetings of the PIRT, and our experts are kind of  
14 on the fence as to whether we can real prove with  
15 confidence that when it's minus seven milli-K that it  
16 really is negative.

17 MR. FLACK: Yeah, I believe that knowing  
18 what drives the uncertainty is what really is  
19 important in understanding what that really is going  
20 to be, and I think that a lot of it is where we're  
21 trying to understand what would be driving that  
22 uncertainty and whether it would overlap.

23 MR. CARLSON: This is enough different  
24 from light water reactor physics that we know that I  
25 think experts just won't immediately come up with an

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1 answer of what they think the expectation is for  
2 accuracy like you're asking. But we could talk  
3 qualitatively about I think there may be substantial  
4 uncertainty in Plutonium-239 and U-235 terms because  
5 the inventory as a function of burn-up is not  
6 perfectly known, for example.

7 MR. FLACK: Why don't we just take this as  
8 a take-away? We'll be meeting more on this in the  
9 future and let's come back on that one.

10 MR. SIEBER: Let me ask just one other  
11 question. There's a lot of resonances in the cross-  
12 section diagrams in the energy range that you're  
13 dealing with here, and when you have one of these  
14 voids, you end up with a pretty good size spectral  
15 shift which steps you through those resonances, which  
16 depending on where you are during that transient will  
17 change whether the coefficient -- what the level of it  
18 is.

19 MR. CARLSON: Well, you'll see that the  
20 dominant resonance absorber, of course, is U-238.

21 MR. SIEBER: Right.

22 MR. CARLSON: And in their table it's a  
23 minus 15 milli-K effect. The change in absorption in  
24 U-238 upon coolant voiding is minute 15 milli-k.

25 MR. SIEBER: Then it comes down like this,

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1 and then there's a bunch of resonances and then it  
2 goes to essentially a mean value again.

3 MR. CARLSON: What's happening is that  
4 when you remove coolant from the channel, more of the  
5 neutrons do their slowing down out in the moderator  
6 away from the fuels who have reduced resonance  
7 absorption.

8 MR. SIEBER: Right, but the burnable  
9 poison has the same phenomenon. If you had gadolinium  
10 it's even wilder than --

11 DR. WALLIS: But that would make it even  
12 more reactive, wouldn't it? If you get less  
13 absorption, you get more reactivity, not less. It  
14 think it must be because you lost the light water  
15 coolant that you --

16 MR. CARLSON: Yeah, I'm thinking about  
17 CANDU here. Excuse me, yeah.

18 DR. WALLIS: I think you've got more  
19 resonance absorption because you've lost the hydrogen  
20 that's doing some slowing down for you in the channel  
21 itself, but again, we're debating stuff. You're going  
22 to sort it out.

23 MR. CARLSON: Yes. So that the coolant  
24 void reactivity is the initial focus of our neutronics  
25 PIRT, and it will be completed in the March-April time

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1 frame.

2 So for completing Phase 2 of the pre-  
3 application review activities on coolant void  
4 reactivity, we'll provide, research will provide an  
5 initial -- we'll apply input on the status and initial  
6 results and plans for coolant void reactivity,  
7 confirmatory analysis to NRR in May, and that will be  
8 used by NRR in responding to AECL in the SAR.

9 DR. WALLIS: Well, tell me. These PIRTs  
10 don't really tell you very much. they tell you that  
11 some experts think that some phenomena is important.  
12 That's fine -- are important. That's fine.

13 But until you actually evaluate it, you  
14 haven't really learned much.

15 MR. CARLSON: Well, in a way our PIRT  
16 panel has not become expert yet in this particular  
17 design, and really at this point the only experts on  
18 the design are at AECL. The rest of us have a steep  
19 curve to climb.

20 So anyway, this is kind of PIRT in the  
21 dark. We have technical discipline area experts, but  
22 they all acknowledge that they have much to learn on  
23 the specifics.

24 DR. WALLIS: So even when you have a good  
25 PIRT, you still have a long way to go.

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1 DR. ROSEN: Of course, the PIRT, all it  
2 does is tell you what to focus on.

3 DR. WALLIS: Right.

4 MR. CARLSON: Yeah.

5 MR. SIEBER: That's right.

6 MR. CARLSON: So as we learn more, we will  
7 refine what we learned from our initial PIRT.

8 DR. WALLIS: I think the real thing is can  
9 the staff calculate the things that matter with this  
10 design with enough confidence to make a decision.  
11 Now, I don't have any measure of that from what I've  
12 heard today. I know it's difficult.

13 MR. CARLSON: Well, and we see it as being  
14 difficult, and we will not provide an answer that,  
15 yes, it is negative during pre-application review.

16 DR. ROSEN: That is kind of a problem for  
17 AECL, isn't it, trying to decide whether to go ahead  
18 with an application? And if it turns out you don't  
19 believe that you can confidently say that it's  
20 negatively, that may be a show stopper.

21 MR. CARLSON: Well, the emphasis of our  
22 early activities continuing into the design  
23 certification phase will be to identify gaps in their  
24 experimental database that would make it difficult for  
25 us to conclude with confidence that it is negative for

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1 the current design or any modified design.

2 MR. FLACK: But, again, I think what we're  
3 trying to do is to see where we're headed as a final  
4 conclusion. Again, the pre-application is part of  
5 being prepared, having the staff prepared, trying to  
6 put the tools in place that will answer that question,  
7 and then when we get to the end of this, we will go  
8 forward with whatever position we're in at that time  
9 with the basis for it.

10 So it could evolve to a policy issue,  
11 uncertainties are large, and we're not as confident as  
12 we believe we could be, but that is to be seen. What  
13 we're at a phase now is just putting in place those  
14 things that will get us that answer, and Don has been  
15 going through with you all of the areas he's looking  
16 at, and we'll continue to look at this as part of pre-  
17 application, and when we come back later this year,  
18 we'll give you our assessment of where we are at that  
19 time. That's about the best we could say at this  
20 point.

21 MR. SIEBER: But it's just as likely that  
22 you can conclude that it's okay as it is that you  
23 would conclude that it's not okay at this point in  
24 time.

25 MR. FLACK: As a basis for either answer.

1 MR. SIEBER: That's right.

2 MR. CARLSON: We know how to get there,  
3 but there's a number of things we have to do.

4 MR. SIEBER: You know you have to cross  
5 fences. You just don't know how high they are.

6 DR. WALLIS: What I'm concerned about is  
7 you're going to be so uncertain that you won't really  
8 know what you're saying about whether it's okay or  
9 not.

10 MR. SIEBER: Well, you can calculate your  
11 uncertainty, too, to some extent.

12 MR. FLACK: We'll have to come to  
13 decisions in light of whatever uncertainties there are  
14 at that time, and it will tell us --

15 MR. CARLSON: We can discuss this more on  
16 the next bullets in the next slide.

17 So we'll be providing initial -- we'll  
18 also be providing a report, the third bullet here on  
19 initial insights and plans for assessing the  
20 neutronics validation data for the coolant void  
21 reactivity, which means evaluating bias and  
22 uncertainty in those predictions and perhaps treating  
23 biases and uncertainties in the safety analysis.

24 No conclusions, just thoughts and  
25 observations based on where we are now in the pre-

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1 application review and where we will be a few months  
2 from now.

3 And then as in all areas, we'll be coming  
4 up with inputs on estimated resources and schedules  
5 for confirmatory analysis of the coolant void  
6 reactivity and validation and related work to  
7 establish core models with the PARCS code for ACR-700,  
8 and that will be in the May-June time frame as well.

9 My last slide, here's our thinking on the  
10 continuation of confirmatory analysis activities for  
11 coolant void and related work from henceforth and into  
12 the design certification phase.

13 Three major activity areas, the first one  
14 being independent static calculations of nominal  
15 values of coolant void reactivity using detailed  
16 models with existing state of the art methods, i.e.,  
17 the MCNP code. MCNP is a Monte Carlo exact geometry  
18 continuous energy point-wise energy code, but it  
19 solves the item value problem static. It's not a  
20 dynamic code. So we will be doing static calculations  
21 of the difference between K effective voided minus K  
22 effective cooled. We started some of that and will be  
23 continuing some of that.

24 So MCMP modeling with in-house cross-  
25 checking against another code, AECL is also using

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1 MCNP. There's another code called MONK. It's from  
2 the U.K. It's very similar to MCNP, but different,  
3 but independent, and uses different cross-section  
4 libraries. They have libraries from Jeff and Jendel,  
5 as well as ENDFB.

6 The second sub-bullet. The results of the  
7 MCMP analysis will reflect and supplement the  
8 phenomenology insights from the PIRT panel.

9 And the final bullet, the detailed MCNP  
10 modeling studies will help qualify the more proximate  
11 models and methods to be used by the NRC nuclear code  
12 suite for reactor transient analysis, SCALE plus  
13 PARCS.

14 The second major bullet, validation and  
15 benchmark analysis to evaluate coolant void reactivity  
16 bias and uncertainty. As I said early on, we expect  
17 bias and uncertainty, the validation question to weigh  
18 heavily on our conclusions in this area.

19 The NRC and DOE have put significant  
20 effort over the last eight years in developing  
21 sensitivity and uncertainty analysis methods for us in  
22 validation in the criticality safety realm. We're  
23 considering adapting and applying those methods and  
24 perhaps other sensitivity and uncertainty methods to  
25 help us assess the applicability and coverage of the

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1 set of semi-prototypic ZED-2 benchmarks, and from  
2 those benchmarks derive the bias and uncertainty in  
3 predicting coolant void reactivity in the reactor.

4 A related exercise is to review and assess  
5 the measurement techniques for ACR benchmarking in  
6 ZED-2. There are some rather unique approaches they  
7 use for those measurements, and we started to  
8 understand them, but the measurements themselves have  
9 potentially significant uncertainties.

10 And the early emphasis of all of these  
11 activities is to try to identify gaps in associated  
12 needs for additional integral data and possibly also  
13 differential data, cross-section data or cross-section  
14 covariance data.

15 The final major bullet. We'll be  
16 providing SCALE lattice data as input to our PARCS  
17 core models for simulating ACR-700 operations and  
18 transience. The substeps include adapting and  
19 applying SCALE, the SCALE Triton code to Model ACR-700  
20 fuel lattices in another yet to be determined sequence  
21 in scale to treat the three dimensional problem of the  
22 transverse reactivity devices. That is, the absorber  
23 rods are perpendicular to the fuel channels, in  
24 between the fuel channels. So that's a three  
25 dimensional problem that we are not used to dealing

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1 with. We do lattice physics in two dimensions for our  
2 current reactors.

3 The corresponding tools in AECL code suite  
4 are WIMS and DRAGON. The second sub-bullet, adapt and  
5 apply PARCS to model the core with lattice data  
6 provided by SCALE, and RFSP is the corollary code for  
7 AECL.

8 And then integrating and testing the  
9 resulting scale data is used in the PARCS models and  
10 then coupling with TRACE and/or RELAP.

11 Once those models are in place, we'll use  
12 those in addition to the AECL codes to analyze the  
13 impacts of postulated CDR variations or uncertainties.  
14 On the progression of cooling transience, the  
15 reactivity response to cooling transience in ACR-700.

16 That concludes my talk. Are there any  
17 questions?

18 (No response.)

19 MS. SOSA: Thank you, Don.

20 At this time I'd like to turn it over to  
21 Mr. Steve Jones, and he will be discussing the on-  
22 power refueling focus topic review.

23 MR. JONES: Good afternoon. I'm Steve  
24 Jones in the Plant Systems Branch of NRR. I just  
25 wanted to speak briefly about the on-power refueling

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1 topic, a little bit more regulatory basis than  
2 technical than perhaps the last couple of  
3 presentations have been.

4 Obviously, on-power refueling has been  
5 previously licensed before in the United States. So  
6 our body of regulations has left some gaps. The  
7 objective is to really fill those gaps with regard to  
8 design criteria, accident evaluation, and, in  
9 particular, the codes and standards that would be  
10 applied to the on-power refueling mechanisms.

11 Now, as Belkys went over, our end report  
12 will deal with regulatory issues, policy issues.  
13 That's probably at times policies just with a small  
14 "P," just dealing with what level of risk is  
15 acceptable for the on-power refueling design.

16 And then develop the regulatory and policy  
17 framework to support --

18 DR. WALLIS: Is that going to be the basis  
19 for it, is to use a risk approach? Are you looking at  
20 things that can go wrong and how they could affect  
21 core damage rather than writing a lot of new  
22 regulations that are ad hoc and the old style?

23 MR. JONES: Our regulations, as I said,  
24 really leave quite a big gap. So it seems like  
25 consistent with our risk informed policy that we would

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1 be using risk to develop any new design criteria that  
2 would apply to on-power refueling.

3 And really the on-power refueling topic is  
4 really a small scale version of the entire design  
5 certification of the plant in that you have a small  
6 pressure vessel that contains irradiated fuel that's  
7 moving around inside containment and then interfaces  
8 with other systems. It affects the reactor accident  
9 frequency because for a time it's part of the Class 1  
10 pressure boundary.

11 But then, again, when it's separate from  
12 the reactor coolant pressure boundary, one previous  
13 speaker mentioned you're only deal with 12 fuel  
14 assemblies, which is one channel, less than one  
15 percent of the core. It doesn't pose a great deal of  
16 consequences considering that that's inside  
17 containment.

18 CHAIRMAN KRESS: But don't the Canadians  
19 have a design basis accidents related to the --

20 MR. JONES: Yeah.

21 CHAIRMAN KRESS: One approach might be to  
22 look at those and say those would be acceptable design  
23 basis concepts?

24 MR. JONES: Yes. We'll get into that in  
25 a later slide. They have provided some design basis

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1 accidents. I'll start at the highest two with our  
2 regulations under Part 50 and Part 52. I gave a  
3 couple of examples where there's some clear  
4 applicability in 10 CFR 5055(a) in codes and  
5 standards, and you've been asking quite a few  
6 questions of AECL regarding the design and the  
7 different points where seals or flexible hoses become  
8 involved in the pressure boundary design of this  
9 plant.

10 And Patrick Sekerak in the Division of  
11 Engineering will be talking about that aspect of on-  
12 power refueling in a moment.

13 One other example is criticality accident  
14 requirements, and that's in Part 5068. It's not  
15 likely to be a real technical issue, but evaluating  
16 how exactly to apply or exempt the on-power refueling  
17 from that particular requirement could be a policy  
18 issue or regulatory issue we need to deal with.

19 The next area is developing a design  
20 criteria, and that's really very well integrated with  
21 the types of accidents that could happen and their  
22 frequency. There's a lot of existing criteria in Part  
23 50, Appendix A that we could apply. Also I'm sure  
24 AECL has developed some criteria that they've used in  
25 designing their own private refueling to date.

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1           The areas we're looking at include  
2           criticality prevention, fuel cooling, residual heat  
3           removal, mechanical handling of the fuel,  
4           instrumentation control systems with regard to those  
5           interlocks and other devices associated with the on-  
6           power refueling machine; to what extent emergency  
7           cooling is required and to what extent containment  
8           integrity is maintained during the fuel transfers.

9           And then from those identify issues,  
10          policy issues which may require high level guidance or  
11          Commission involvement.

12           DR. WALLIS: Has AECL left this up to you?  
13          I would think that in their submission they would say,  
14          "Here's our reactor, and this is why it meets your  
15          general design criteria."

16           MR. JONES: We did have actually our first  
17          technical meeting yesterday regarding our on-power  
18          refueling, and we discussed that it would greatly  
19          simplify matters to get their proposed design criteria  
20          and just evaluate whether or not those are acceptable,  
21          but as we have already a set of design criteria in  
22          Appendix A, it doesn't seem entirely out of the scope  
23          of our work to also propose some for this type of  
24          application.

25           DR. WALLIS: I just thought they would

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1 have already come in saying all you had to do is see  
2 whether you accept it or not. It doesn't seem that is  
3 the case.

4 MR. JONES: In the documents I have  
5 reviewed to date, I haven't seen any set of design  
6 criteria specifically --

7 DR. RANSOM: It seemed like that would  
8 want to trade off the risk due to decay heat removal  
9 and low power operation, which I understand there are  
10 significant risks in conventional plants versus not  
11 having to go through that phase.

12 MR. JONES: That's true. That would be an  
13 opportunity.

14 DR. ROSEN: Well, not having to go through  
15 that phase as often.

16 DR. RANSOM: Pardon?

17 DR. ROSEN: Not having to go through that  
18 phase as often.

19 DR. RANSOM: Right, right.

20 DR. ROSEN: We do have to shut down at  
21 some point, and then they have shutdown risk issues,  
22 not the same ones we have, clearly, but there do shut  
23 down after three years.

24 MR. JONES: I guess the dominant  
25 contributor as far as mid-loop operation with fuel

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1 still in the reactor vessel would largely be avoided  
2 in this design. So that's a big part.

3 The other issues, as Dr. Kress mentioned,  
4 with review of operating experience and failure modes  
5 analysis of their basic design to identify proposed  
6 design basis events and bring risk elements in to see  
7 how likely any one of those design basis events were,  
8 and from that establish acceptance criteria for the  
9 accident analyses involving the fuel handling machine.

10 Again, there may be some policy issues  
11 that arise out of that. Since we're dealing with a  
12 very small fraction of the core, the risk or the  
13 consequences are relatively low. However, they are  
14 different from what we have licensed in current plants  
15 where we're only looking at mechanical damage of, for  
16 instance, one PWR assembly which is at least on the  
17 same order of magnitude as far as amount of irradiated  
18 material, but we're only looking at gap releases in  
19 those type of events, filtered through some amount of  
20 water, whereas it seems as though at least accidents  
21 in this refueling machine could involve thermal damage  
22 to fuel that involves a larger release, and we'd just  
23 have the containment boundary as a protected  
24 mechanism.

25 Regarding technical issues as far as

1 that's really the methods of review and analytical  
2 tools, I really don't see many issues in that area.  
3 Right now this is pretty traditional accident analysis  
4 work or risk evaluations, but we'll be looking for  
5 those items and identifying any in the safety  
6 assessment report.

7 And that concludes my portion of the  
8 presentation.

9 Mr. Sekerak from Division of Engineering  
10 will talk briefly about the Part 5055(a) code and  
11 standard applicability to on-power refueling.

12 MS. SOSA: Thank you.

13 MR. SEKERAK: Good afternoon or good  
14 evening might be more appropriate. My name is Patrick  
15 Sekerak. I'm from NRR, Division of Engineering,  
16 Mechanical Engineering Branch.

17 And my part of this review is specifically  
18 related to review of the qualification and design of  
19 the mechanical equipment that's associated with the  
20 on-power refueling system, and much of what Steve  
21 provided you just before is applicable to my area, but  
22 what I wanted to concentrate on in the interest of  
23 brevity was the specifics of what I'm particularly  
24 concerned about in reviewing the mechanical design  
25 basis of the components and component supports that

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1       comprise on-power refueling equipment.

2               So far the most detailed document that has  
3       been submitted by AECL for on-power refueling is the  
4       AECL report, "The Technology of On-power Refueling."  
5       What this document provides is a very good, general  
6       description of the qualitative portions of the system  
7       and how the system works, how the components relate to  
8       each other, and it's a good general description, and  
9       it also provides some reference to CSA standards that  
10       are supplementing the ASME design standards that we  
11       use as part of our regulations.

12               And in that regard, it's useful because it  
13       provides some basis for our understanding of a design,  
14       quite frankly, that I'm very unfamiliar with.  
15       However, what it does not provide is the level of  
16       quantitative design basis information that I need to  
17       pass judgment on the design basis for the equipment it  
18       constitutes, the on-power fueling system.

19               That kind of information, and I refer to  
20       10 CFR 5247 for reference, that type of information is  
21       by this litany of information that I have under the  
22       second paragraph, which should not be interpreted as  
23       all inclusive by any means, but gives a representation  
24       of the type of detailed design criteria and  
25       information that I'm going to need in order to do a

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1 technical review for design certification purposes.

2 Now, the path forward for staff review of  
3 this kind of information is Chapter 3 of the standard  
4 review plans, the NUREG 0800, and it's represented  
5 primarily by standard review plans, such as 3.2.2,  
6 3.9.1, 3.9.2, 3.9.3, and 3.9.6.

7 That is the plan that I will be using for  
8 review of the design adequacy of this kind of  
9 equipment and supports, and one thing I'd like to  
10 highlight. Probably the most important thing that  
11 those standard review plans rely upon is the ASME  
12 boiler and pressure vessel code as the document that  
13 defines the acceptance criteria and design basis for  
14 mechanical equipment.

15 And the policy issue, although I list it  
16 as a policy issue, it could be a regulatory issue, but  
17 I'll consider it a policy issue for now because it  
18 concerns me because what we've been told is that there  
19 are a number of departures from 10 CFR 5055(a) which  
20 constitutes the adoption of the ASME design code as  
21 the rule for design of components that provide  
22 pressure boundary, Class 1 pressure boundary, and  
23 supports for the Class 1 pressure boundary, and we're  
24 told that there are a number of CSA standards that are  
25 being used as proposed alternatives to these ASME code

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1 requirements.

2 I know that there are a number of  
3 components in the on-power fueling system that fall  
4 into that category. There are also some components  
5 that will be affected in the Class I pressure boundary  
6 design, and there may be others. I'm not sure of the  
7 full extent of where those alternatives to the ASME  
8 code really are applicable.

9 I know that in the Class I pressure  
10 boundary design and on-power fueling equipment design  
11 that they are applicable, and what I'm concerned about  
12 is that there has to be some reconciliation formally  
13 of these CSA standards when they provide for either  
14 replacement of ASME standards or supplementation of  
15 ASME standards or provision of new standards, adding  
16 to the ASME code requirements.

17 The first thing that I would have to do  
18 when it comes actually time to write a safety  
19 evaluation report, the first paragraph that I'm going  
20 to write is what are the acceptance criteria.  
21 Ordinarily that would be fairly easy. I'd just refer  
22 to the general design criteria, standard review plan  
23 guidelines, the regulatory guidelines, and then I  
24 could proceed to the detailed review of the kind of  
25 information that I would expect from the second

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1 category of the slide, the 5247 design information.

2 But I've got a problem right away. In the  
3 first paragraph of the safety evaluation report that  
4 I'm writing, I've got to reconcile somehow the  
5 acceptability of the CSA standards. Now, 10 CFR  
6 5055(a) provides for the NRC review and acceptance of  
7 proposed alternatives to 10 CFR 5055(a).

8 But what I'd like to emphasize is that it  
9 also suggests that the burden of proof of the  
10 acceptability of those standards in providing an  
11 acceptable level of quality and safety to codes that  
12 it is replacing, that burden of proof rests with the  
13 applicant. And I would emphasize that for AECL  
14 consideration.

15 What we would expect, what the staff would  
16 need in order to proceed with this kind of review in  
17 an efficient manner is to have those proposed  
18 alternatives or exemptions of whatever form they take,  
19 proposed in the process adjusted by 10 CFR 5055(a),  
20 and especially with regard to providing justification  
21 that the CSA standard provide an acceptable level of  
22 quality and safety to the provisions of the ASME code  
23 that it is replacing or supplementing.

24 As I mentioned before, the AECL report,  
25 "Technology of On-power Refueling," I find to be a

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1 very useful document to provide an overall  
2 orientation. However, for my purposes it's long on  
3 system description; short on technical details. And  
4 before I can really proceed any further, I would need  
5 much more detailed technical design basis information  
6 and also a basis to establish an agreed upon  
7 acceptance criteria where there are departures from  
8 the ASME boiler and pressure vessel code which  
9 includes not only Section 3, but Section 11 and the  
10 operation and maintenance codes, which are also  
11 adopted by reference in 10 CFR 5055(a).

12 DR. ROSEN: And the code cases.

13 MR. SEKERAK: And code cases that would be  
14 applicable.

15 DR. ROSEN: Well, one was mentioned this  
16 morning, risk informed code case, risk informed  
17 inspection code case.

18 No, I think your analysis here is very  
19 useful, very thoughtful, and difficult obviously for  
20 AECL implications. But there is another way for AECL  
21 to approach it perhaps just as hard or even harder  
22 unfortunately and that's for them to go to the ASME  
23 code and get that reconciliation adopted in code  
24 cases, which would solve your problem, wouldn't it?

25 MR. SEKERAK: It would in theory.

1       However, in practice, having participated in the ASME  
2       process as a new code committee member, the process  
3       sometimes is very lengthy. I would be concerned about  
4       the length of time that it would take to get code  
5       cases approved to support the kind of scheduling that  
6       both AECL and the project is --

7                   DR. ROSEN:    Oh, I agree with you 100  
8       percent. I just think that if you just leave the time  
9       scale off the axis for a moment, but stepping through  
10      that process, if AECL was to identify the deviations  
11      or differences with the code, the ASME boiler and  
12      pressure vessel code and its O&M cases and the rest of  
13      it, identify those, go to the code communities, get  
14      code cases that say, yes, it's acceptable if you do  
15      this or that and whatever the conditions are; then  
16      you're back in what you said. When you sit down, you  
17      can evaluate it.

18                   MR. SEKERAK: I would agree that ignoring  
19      the pressures of schedule, that would be a good way to  
20      proceed because it would address ASME, who would  
21      really have the depth of knowledge to address the  
22      differences and to be able to make judgments about  
23      whether or not the applicable CSA standards had the  
24      same design basis that the code does, the same  
25      implicit factors of safety, and the various other

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1 technical provisions that I would be looking for as a  
2 justification that the CSA standards provide  
3 equivalency to the ASME standards.

4 DR. ROSEN: And leaving out the time  
5 scale, which brings in the consensus process, which is  
6 very useful.

7 MR. SEKERAK: Yes, it does, and the ASME  
8 code, obviously, has developed as a consensus code  
9 over decades. We're familiar with it. Many of us  
10 have used it. We participate in the consensus review  
11 process. So we're comfortable with it.

12 When standards that deviate from it are  
13 introduced in our review, that provides another  
14 challenge, and I'm not saying that that necessarily is  
15 a showstopper. I don't even know enough about the CSA  
16 standards to even suggest that.

17 But it provides an additional challenge  
18 right up front to agree on acceptance criteria which  
19 would otherwise be very clear for us, and I would  
20 certainly like to have that acceptance criteria tied  
21 down specifically before I even spend an hour on  
22 reviewing a design certification, the details of a  
23 design certification application.

24 So those are the major points that I  
25 wanted to emphasize in my view of what I have done in

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1 this regard so far. So if there are any other  
2 questions, I'd be glad to try to answer them if I  
3 could.

4 MS. SOSA: Before we move from this topic  
5 I'd like to clarify a couple of things. Part of the  
6 issues that you heard today from Mr. Sekerak are  
7 things that we are addressing in Phase 2. The main  
8 objective of Phase 2 is to provide the type of  
9 feedback that he expressed here today.

10 So hopefully we will come to good  
11 solutions. There are multiple ways to resolve this  
12 issue. However, the schedule is a very important  
13 consideration.

14 So we're hoping to proceed with a plan  
15 that works.

16 DR. ROSEN: Schedule is very important for  
17 AECL, clearly, but overriding it is the question of  
18 the consistency of this design with our requirements  
19 and the ability to find confidently that the design  
20 does meet those requirements. So, I mean, that has to  
21 be first, and then if you can do that on their  
22 schedule, so much the better, but first things first.

23 MR. SEKERAK: And this is especially  
24 important since a major section of our regulations are  
25 devoted to this very topic. The ASME code has become

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1 enshrined in the basis for our regulations for a long  
2 time, and I would need some detailed information about  
3 reconciliation of requirements that would convince me  
4 that any new CSA standards that are proposed, in  
5 fact, do have a sound design basis.

6 And if there are departures from design  
7 factors, for example, implicit in the ASME III code,  
8 then I would expect some justification of why those  
9 design standards or departures from those design  
10 factors are compensated for by other provisions.

11 And without belaboring that point too  
12 much, just to provide an example, the ASME III code  
13 has implicit in it a design factor of approximately  
14 three, which is measured by the allowable stresses  
15 that are specified by the code compared to the minimum  
16 material properties that are measured in the code  
17 approved materials.

18 If a design standard is provided that has  
19 a smaller design factor implicit in it, it would not  
20 necessarily be unacceptable, but there would have to  
21 be a justification of why that lower design factor is  
22 -- what compensates for that particular lower design  
23 factor? Is it more stringent requirements on material  
24 procurement, material inspection, fabrication  
25 requirements? What are the compensating factors that

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1 would allow me to accept a design code that has a  
2 lower implicit design factor?

3 And that's just an example of the kinds of  
4 detail that I think would be necessary in order to  
5 justify departures from 10 CFR 5055(a) requirements.

6 MS. SOSA: Thank you.

7 MR. SEKERAK: Thank you.

8 MS. SOSA: And last on today's agenda we  
9 have Mr. Martin Stutzke, and he will be presenting the  
10 staff review for the PRA.

11 MR. STUTZKE: Hi. I'm Marty Stutzke. I  
12 work for the Probabilistic Safety Assessment Branch in  
13 the Office of Nuclear Reactor Regulation. I have been  
14 there about seven months now. Prior to that I had 17  
15 years as a private consultant doing PRAs.

16 So my perspective may be a little  
17 different, and my boss is helping me to learn.

18 DR. WALLIS: Are you just learning from  
19 your boss or is it the other way around?

20 (Laughter.)

21 MR. STUTZKE: Hopefully it's mutual.

22 I have two major things I'd like to  
23 present to you today. First of all is our plan to  
24 conduct our review, the objectives, the guidance, the  
25 various assignments and schedules and things like

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1 that.

2 The second thing is what I will label to  
3 say potential policy issue concerning risk acceptance  
4 guidelines for core damage frequency.

5 The objectives are pretty much as you  
6 would expect. We want to determine that the PSA  
7 methodology will produce a PSA with adequate scope,  
8 adequate level of detail, and technical acceptability.  
9 Along the way, as Belkys has told you, we need to  
10 identify potential issues, technical regulatory  
11 policy.

12 Finally, we've been asked to generate a  
13 schedule and resource estimate for actually reviewing  
14 the PRA when it has been submitted. As you point out  
15 now, what we have to work with are PRA methodology  
16 documents. We have a reference analysis for the CANDU  
17 6 and the CANDU 9. I have not seen any PRA or any PRA  
18 results for the ACR-700 as of this time.

19 Finally, we need to learn about the ACR-  
20 700 design, the plant layout, the construction. The  
21 systems are somewhat similar, and deceptively  
22 different sometimes.

23 When I was a private consultant, I did PRA  
24 work in Romania on a CANDU plant. So what I learned  
25 by that exercise was if you go in with preconceived

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1 notions, you generate the wrong answer and identify  
2 the wrong risk contributors.

3 So we need to be a little bit careful that  
4 we understand how it works before we try to attack how  
5 it fails and model that correctly.

6 DR. FORD: Did you say that you haven't  
7 received the PRA from the applicants for this ACR-700?

8 MR. STUTZKE: That's correct.

9 DR. FORD: And yet you're supposed to  
10 write something by July?

11 MR. STUTZKE: I'm supposed to write on the  
12 methodology of the PRA.

13 DR. FORD: Ah.

14 MR. STUTZKE: Yes, it's a little sporty.

15 DR. WALLIS: There's nothing there about  
16 their competence to use the methodology? I can say  
17 I'm going to use all the best textbooks and all of the  
18 best methods, but I may be totally incompetent in my  
19 use of them.

20 MR. STUTZKE: Let me address that when we  
21 talk about the PRA quality issue because I think that  
22 has some bearing on this.

23 The next couple of slides I will just flip  
24 through them with your permission because they talk  
25 about the general sorts of guidance that I'm using to

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1 help do my work.

2 Notice with respect to PRA quality, the  
3 sections out of Reg. Guide 1.174, the standard review  
4 plan Chapter 19 and specifically Chapter 19.1; the  
5 ASME and ANSI standards on PSA; and last but not  
6 least, Regulatory Guide 1.200. This was formerly  
7 draft Regulatory Guide DGL 1122 whose publication is  
8 imminent I've been told.

9 PARTICIPANT: It's more. The Reg. Guide  
10 1.200.

11 MR. STUTZKE: So here's what's been done  
12 before. First of all, you should realize this is a  
13 joint effort between our branch and the PRA branch and  
14 the Office of Research being head up by John Ridgely  
15 over there.

16 We've issued an RAI concerning PSA  
17 quality. They had a short chapter in their  
18 methodology document, and I asked some questions, how  
19 they intended to do this.

20 Very recently, between Christmas and New  
21 Year's, we issued some advice or guidance on our  
22 expectation. Specifically what I did was identify to  
23 them when Regulatory Guide 1.200 had been entered into  
24 the ADAMS system so that they could access it and  
25 become acquainted with it like this.

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1 I advised AECL that we have a project in  
2 our branch called the PRA quality pilot projects where  
3 we intend to test the regulatory guide with five or  
4 six applications. I'm certain you're aware of that.  
5 It has been coordinated through the NEI, and I wanted  
6 to make AECL aware that this was going on.

7 CHAIRMAN KRESS: Does that guide give  
8 guidance on how to do uncertainty?

9 MR. STUTZKE: No.

10 CHAIRMAN KRESS: Well, that would be a --

11 MR. STUTZKE: It's not a methodology  
12 document per se. It says you should do uncertainty,  
13 and here are the types of uncertainties to come.

14 CHAIRMAN KRESS: It doesn't tell you.  
15 Does the methodology document have any guidance?

16 MR. STUTZKE: The methodology document  
17 constrains itself to parametric uncertainty,  
18 variations in failure rates and propagating, that sort  
19 of thing.

20 Within the next six weeks research will  
21 give me their draft report where they have reviewed  
22 the generic methodology and the generic PSA analyses,  
23 the so-called reference analyses, as well as the ACR  
24 PSA methodology report. I understand research has  
25 engaged a contractor to help them out; is that right?

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1 I think it's somebody at Oak Ridge, but I don't know  
2 the details. It's not important.

3 Towards the middle of April we'll get  
4 together with research and the contractor and finalize  
5 their report so that they will have met their  
6 deliverable to me.

7 Towards the middle of May I will complete  
8 our review of the ACR PRA methodology. Another  
9 report, which is the "Phenomenology of Limited and  
10 Severe Core Damage Accidents." The review here is not  
11 nitty-gritty details of Level 2 PSA. It's more  
12 towards understanding what phenomenology accident  
13 progression really looks like to make certain we  
14 understand what they're telling us.

15 An additional report in here AECL will  
16 prepare, the latest target date is March 1st, is a  
17 document that discussed how they've used the PRA and  
18 the design ACR. That was originally scheduled, I  
19 believe, this fall, and it has been slipped for some  
20 time. We are very interested to see this document.

21 So towards the end of April, we'll  
22 complete our schedule and resource estimate, and then  
23 at the end of March or -- excuse me -- the end of June  
24 here complete our deliverable to the project manager  
25 of Belkys.

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1                   Okay. Here's our potential policy issue.  
2                   Staff requirements memorandum on SECY 9016 specifies  
3                   a core damage goal of ten to the minus four per year  
4                   for evolutionary and advanced reactor designs. The  
5                   ten to the minus four per year, Professor Apostolakis  
6                   addressed that earlier today. AECL has a target of  
7                   ten to the minus five per year. Okay? So they're  
8                   designing to one order of magnitude lower than what we  
9                   think is necessary.

10                   I shouldn't say "what is necessary." To  
11                   our current acceptance guideline.

12                   MR. SIEBER: Like this so you can make it  
13                   more risky.

14                   DR. WALLIS: Of course, making it safer is  
15                   totally unacceptable.

16                   DR. ROSEN: You should use the words  
17                   "frequency goal." Don't try to interpret it. It gets  
18                   you in big trouble. It's the goal.

19                   DR. WALLIS: Not even to be achieved.

20                   DR. ROSEN: Goals are good things.

21                   MR. STUTZKE: Now, for the ACR-700, as in  
22                   other CANDUs, AECL has divided the core damage  
23                   accidents into two broad categories: limited core  
24                   damage accidents where the progression of the accident  
25                   has arrested within the fuel channels, okay, so that

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1 you're talking about single channel sorts of problems.

2 DR. WALLIS: Is that core damage or not  
3 core damage?

4 MR. STUTZKE: This is the root of my  
5 question.

6 DR. ROSEN: To the operator that's core  
7 damage.

8 CHAIRMAN KRESS: To the PRA it's not.

9 MR. STUTZKE: Severe core damage --

10 MR. SIEBER: It's short of core damage.

11 MR. STUTZKE: -- it's traditional LWR  
12 accident progression.

13 CHAIRMAN KRESS: The definition of core  
14 damage in the U.S. involves significant amounts of  
15 fission product.

16 DR. WALLIS: That's my understanding, too.

17 MR. STUTZKE: That's my question, is how  
18 significant is significant.

19 Let me continue a little bit.

20 DR. WALLIS: Maybe you guys should give an  
21 answer to it.

22 MR. STUTZKE: In their PRA methodology,  
23 they define ten plant damage states. Okay. That with  
24 actually one plus exception they map to either limited  
25 or severe core damage categories. They have a plant

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1 damage state number nine that pertains to tritium  
2 release that does not involve any fuel damage at all.

3 Okay?

4 For example, what if you get a pipe break  
5 in the moderator system? What if you get a hydrogen  
6 fire or explosion in the surge tank to the moderator  
7 system? Things like this.

8 The plus I had talked about is what about  
9 refueling accidents. Okay? They're single channel,  
10 that volume of fuel, but they could be inside the  
11 reactor core; they could be outside the core or  
12 somewhere in between like this.

13 Now, my understanding of their methodology  
14 is they have the capability of calculating frequencies  
15 for each one of these plant damage states because they  
16 are nothing more than the end states. So it's a  
17 matter of telling the computer go ahead and calculate  
18 the answer.

19 I have also, as part of one of my RAIs,  
20 requested they try to calculate the uncertainties for  
21 each one of these things. My purpose here is I wanted  
22 to understand what the magnitude of the frequencies  
23 were and what the risk drivers were for each one of  
24 these point damage state directives at this point.

25 This leads me to a question. How do I

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1 interpret the ten to the minus four core damage  
2 guideline? In AECL's thinking, and I think in most of  
3 our branches' thinking, the guideline applies to  
4 severe core damage. Okay?

5 It raises the question: well, what about  
6 the limited core damage frequencies? Do we merely  
7 calculate them? Do we try to compare them to some  
8 sort of a target? If so, what target?

9 CHAIRMAN KRESS: My advice there would be  
10 go to the regulatory framework for risk informed  
11 regulations and see if you can find a target there.

12 MR. STUTZKE: I appreciate that. Yeah,  
13 we'll look.

14 On the other hand, if it applies to the  
15 total, you have the question on the other end: do  
16 you need a percentage sort of thing, say, severe is  
17 some percentage for the total core damage?

18 My personal leaning, as I said, is towards  
19 the interpretation above the first interpretation that  
20 severe core damage frequency target.

21 The second question that I have is: what  
22 about these accidents that involve potential releases  
23 but no fuel damage at all, like tritium releases?  
24 Okay. My instinct tells me they're probably of a much  
25 smaller consequence than severe core damage, but the

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1 frequency may be higher. I just don't know at this  
2 point in time.

3 CHAIRMAN KRESS: That needs to be looked  
4 at.

5 MR. STUTZKE: It needs to be looked at.

6 CHAIRMAN KRESS: And I think you're going  
7 to need some sort of acceptance criteria. Otherwise  
8 your safety analysis is not complete.

9 MR. STUTZKE: That's correct. That's my  
10 feeling.

11 Any other questions?

12 DR. ROSEN: Acceptance criteria that  
13 doesn't lead to success criteria for the mitigating  
14 systems and track back into the analysis.

15 MR. STUTZKE: Yeah, slowly.

16 MR. SIEBER: Well, that really just boils  
17 down to what health effects there are, in other words,  
18 fatalities, and depending on the level of tritium  
19 release, I guess if you do anything there is some  
20 latent effect, but do you consider the whole world?

21 CHAIRMAN KRESS: Well, the --

22 MR. SIEBER: You end up with one.

23 CHAIRMAN KRESS: That's one of the things  
24 that they wrestled with in the risk informed  
25 framework.

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1 MR. STUTZKE: Yes.

2 CHAIRMAN KRESS: And they have guidelines  
3 in there, and it would apply to the tritium just as  
4 well.

5 MR. STUTZKE: Right.

6 MR. SIEBER: I think that's the way to  
7 resolve that.

8 CHAIRMAN KRESS: Yeah. Those aren't  
9 regulations.

10 MR. SIEBER: No, they aren't.

11 CHAIRMAN KRESS: You may be faced with you  
12 don't have the information.

13 MR. STUTZKE: But it's some guidance.

14 MR. SIEBER: It's the rationale that has  
15 been used before. That's about the best you can say.

16 MR. STUTZKE: But correct me if I'm wrong.  
17 That guidance is in terms of dose.

18 CHAIRMAN KRESS: Since there's a dose and  
19 that's what made you apply it to these things, and  
20 it's a frequency associated with giving doses.

21 MR. STUTZKE: Yes, sir.

22 CHAIRMAN KRESS: It's almost an LF type  
23 curve like they can use anyway, but it would be well  
24 worth checking into to see if you can use it.

25 MR. SIEBER: Yeah.

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1 CHAIRMAN KRESS: It doesn't have the power  
2 regulation.

3 MR. STUTZKE: But I think it's better than  
4 nothing.

5 Okay. That's all I have for you.

6 DR. ROSEN: Well, I have a question --

7 MR. STUTZKE: Yes, sir.

8 DR. ROSEN: -- about using the -- you  
9 listed all of the standards, the ASME internal event  
10 standard and the ANS low power and shutdown standard.  
11 Buried in that ASME internal event standard is a  
12 requirement for peer review.

13 MR. STUTZKE: Yes, that's correct, and I  
14 asked as part of my RAI what is AECL's intentions with  
15 respect to some sort of peer review, specifically to  
16 ACR or has other of their work ben peer reviewed,  
17 something that we can point to that may demonstrate  
18 compliance with the standard.

19 We have a meeting with AECL. I believe  
20 it's February 5th to discuss these questions.

21 DR. ROSEN: I'll be interested in the  
22 answer.

23 MR. STUTZKE: And me, very much.

24 MS. SOSA: Last, in summary, we'll present  
25 the schedule and the major milestones, and that

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1 presentation will be by Jim Kim.

2 MR. KIM: This is Jim Kim from the NRR,  
3 your reactors project office.

4 If I look at the presentation, I look back  
5 at the AECL and I'll just thank for their  
6 presentations and I also like to thank committee  
7 members for the feedback on these subjects.

8 As we know we are already in Phase 2 of  
9 the pre-application phase and so far up to date, ACR  
10 has been submitted more than 160 documents in support  
11 of the pre-application review. And we have requested  
12 REIs on physics, thermal hydraulics, and quality  
13 assurance, and PRA, and also we requested additional  
14 information in support of the PIRT process, and so far  
15 we have received the responses on thermal hydraulics,  
16 physics, and PIRT, and we'll be receiving QA responses  
17 in two weeks, which is end of January.

18 DR. FORD: There have been no RAIs on  
19 materials?

20 MR. KIM: We are expecting several more  
21 RAIs, especially on pressure boundary design and  
22 several other subjects.

23 We have to request the RAIs by end of  
24 March in order to get the responses from AECL by the  
25 end of April. That is the time frame that we have at

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1 this time.

2 And today we are conducting ACRS  
3 information briefing, and we have a window of  
4 opportunity between April and June in order to conduct  
5 the ACRS subcommittee meetings on possibly thermal  
6 hydraulics and PRAs and possibly material issues.

7 And the end product of the pre-application  
8 is to produce a draft safety assessment report by end  
9 of July, and we are currently forwarding the draft SAR  
10 to both ACRS Committee and OGC for their concurrences.

11 And we will conduct the full committee  
12 meeting in September, and after concurrences will  
13 issue the final SAR to the AECL.

14 CHAIRMAN KRESS: We will try to  
15 accommodate your needs for the ACRS review.

16 MR. KIM: Thank you.

17 CHAIRMAN KRESS: Because we consider this  
18 one of the more important things.

19 MS. SOSA: Thank you.

20 CHAIRMAN KRESS: Did you want to?

21 MS. SOSA: Yes. I'd like to give an  
22 opportunity to Mr. Jim Lyons to express some closing  
23 remarks.

24 MR. LYONS: Thank you.

25 It's good to see I'm appreciated some

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1 places.

2 I'm Jim Lyons. I'm with the new reactor  
3 licensing project.

4 I'd like to thank you all for your time  
5 and attention today. We've got through a lot of  
6 material, and we've seen a lot of really good  
7 questions and a lot of good issues discussed here.

8 I'd like to reemphasize that this pre-  
9 application review is meant to address those technical  
10 and policy issues that AECL has identified for the  
11 most part and in some cases we've identified that  
12 should be resolved prior to them actually coming in  
13 for a design certification application.

14 As you've seen, we're in various stages of  
15 our review on different focus topics. On some of the  
16 issues we've had a lot of interactions and we're  
17 fairly far along. On some we're just really getting  
18 started. And so a lot of what you're hearing from the  
19 staff today is trying to understand how are we going  
20 to review the ACR-700 which was designed, you know,  
21 without our regulations in mind and trying to apply  
22 our regulations.

23 And so a lot of it is reconciling those  
24 differences, and so that's one of the challenges that  
25 the staff is faced with and that I think you're

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1 hearing as we go through here, and I think it's  
2 something that we're going to continue to work on.

3 And AECL has been very good about giving  
4 us as much information as we need, as we've asked for.  
5 We're very happy with that. We're moving forward.

6 We're trying to work this -- I shouldn't  
7 say "trying" -- we're working well with the Canadian  
8 Nuclear Safety Commission to have them help inform us  
9 on what some of the key issues we should be looking at  
10 and trying to help us focus our reviews and to give us  
11 the benefit of their experience with the CANDU design.

12 So with that, again, I'd like to thank  
13 everyone for their time and attention.

14 CHAIRMAN KRESS: We'd like to thank  
15 everyone for these very good and informative  
16 presentations. Very useful to us.

17 At this stage in a subcommittee meeting,  
18 quite often we'll go around the table and seek initial  
19 comments from members on what they think so far. I  
20 think this may be too early a phase to do that.

21 So instead what I'll do is give anybody on  
22 the committee the opportunity to speak up if they have  
23 some sort of thoughts that they'd like to express or  
24 burning issues or they see anything so far that they  
25 wish to comment on.

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1                   So I'll throw it open to you. I'm not  
2 going around the table and say, "You, you, you, and  
3 you."

4                   DR. WALLIS: Am I allowed to say something  
5 then?

6                   CHAIRMAN KRESS: Well, definitely.

7                   DR. WALLIS: I was really fascinated by  
8 the AECL presentation. I think it was a good  
9 presentation. You know, from their point of view,  
10 this is something they have a lot of experience with,  
11 and it looks like a nice design.

12                   I just think that you've probably  
13 underestimated the need you have to cost your  
14 application in terms of the language and the terms and  
15 the measures that these fellows here in Washington are  
16 familiar with. You have to make a lot of effort to  
17 turn it into things they understand. Otherwise they  
18 just keep coming back asking you questions, and you  
19 won't reach resolution.

20                   So you've got to make more of an effort,  
21 I think to understand what it is and the language that  
22 they speak and the way that they think.

23                   And I'm really uncertain from hearing  
24 about what the staff said. I understand and I was  
25 pleased to hear that many of these members realize

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1 what they're up against. I can't see whether or not  
2 they're going to be able to resolve some of these  
3 issues. I mean, they raise the questions, but they  
4 don't give me any measure of how likely it is that  
5 they're going to be resolved. So this is very much an  
6 open -- it's sort of a suspense story without an  
7 indication of where it's likely to go for me.

8 And I almost feel there's a need for sort  
9 of a regulatory interpreter between these two sides of  
10 saying, "Can't we do it this way for the NRC so that  
11 they can understand what you're doing? And can you do  
12 it this way for the NRC so they can understand it?"

13 So it's something sort of in between.

14 CHAIRMAN KRESS: That would be a good job  
15 for Ken Rogers.

16 DR. WALLIS: Ken Rogers, yeah. I was  
17 thinking of Ken Rogers, yeah, right.

18 Because it would be a real pity that just  
19 because, as you speak different languages, in  
20 technical languages or regulatory languages you can't  
21 sort of get an agreement about something which may  
22 well be a nice technical piece of equipment.

23 CHAIRMAN KRESS: I appreciate those  
24 comments.

25 Yes, sir.

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1 DR. FORD: Could I make a comment because  
2 both the --

3 CHAIRMAN KRESS: Does it have anything to  
4 do with materials?

5 DR. FORD: It sure does.

6 (Laughter.)

7 DR. FORD: Because both the staff and the  
8 applicant asked for advice as they go into this,  
9 finish their pre-application stage.

10 Someone asked are there any burning  
11 materials issues which are drop dead. I don't see  
12 that there are any issues which are drop dead issues  
13 at this stage. The ACR-700 is an evolutionary design.  
14 It has got good CANDUs. It has got a good operational  
15 record.

16 The staff are asking the right questions  
17 as far as materials issues. I'm astonished, however,  
18 that there have been no RAIs at this stage. The  
19 concern I have is the complete lack of quantification  
20 on both sides to quantify the kinetics of materials  
21 degradation and their consequence.

22 All of the materials degradation modes  
23 delay hydrogen cracking, erosion-corrosion, test  
24 corrosion, corrosion fatigue, they've all been  
25 highlighted, and they must increase in probability of

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1 occurrence because of the increase in temperature.  
2 All of them are thermally activated processes.

3 The remedial actions of changing material  
4 and/or the dimensions are the right direction to go,  
5 but I see no quantification as to the fact of  
6 improvement of going in those directions, and I think  
7 that at this stage from both the regulatory point of  
8 view and operational point of view, you need to  
9 quantify those kinetics, not only the individual modes  
10 of degradation, creep, DHC, et cetera, but the  
11 interaction of those modes, start-up, shutdown, and  
12 also for accidents.

13 the other area that I was dismayed at not  
14 having a lot of information is inspection criteria.  
15 I like the reference to the risk informed, but I saw  
16 no data to back up that hope.

17 Those are the hopefully constructive  
18 comments I have to make.

19 CHAIRMAN KRESS: Anybody else feel  
20 compelled to say some words?

21 MR. LEITCH: Yeah, I had a question. I  
22 didn't hear a whole lot about emergency electric power  
23 supply. I suppose there are diesels required, but I  
24 don't know how big they need to be, what the starting  
25 requirements, starting times for those diesels are.

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1 So I guess at some future time I'd like to hear a  
2 little bit more about the emergency electric power  
3 supply.

4 Also, I didn't hear -- and this may be  
5 beyond the scope of our discussion here, but I didn't  
6 hear anything at all about considerations regarding  
7 safeguards and security. You know, at this early  
8 stage of design, this may be a time when some  
9 significant progress could be made in designing the  
10 plants to take into consideration some of the  
11 safeguards and security issues.

12 CHAIRMAN KRESS: Yeah, I had in mind the  
13 potential vulnerability in the spent fuel pool there.

14 MR. LEITCH: Yeah.

15 CHAIRMAN KRESS: The containment looks  
16 like it's pretty good.

17 MR. LEITCH: And I guess I'd like to hear  
18 a bit of a sales pitch, a commercial. I mean, I see  
19 the advantages of on-power refueling and the operating  
20 flexibility that that achieves, but I didn't hear any  
21 discussion -- and, again, maybe it's beyond the scope.  
22 It's not really a safety issue perhaps -- but why  
23 should a utility be interested in buying one of these  
24 machines? Is it low construction cost, low operating  
25 cost, load following capability or just maybe there

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1 are some of those advantages that are just not clear  
2 to me. They just haven't been emphasized. I'm just  
3 not sure what those --

4 MR. SIEBER: I think that's probably  
5 beyond the agency's concern.

6 MR. LEITCH: Well, as I say, maybe it may  
7 not be a safety issue, and it may be --

8 MR. SIEBER: It certainly isn't.

9 MR. LEITCH: -- beyond the scope of this  
10 discussion, but I'd like to hear a little bit about  
11 the advantages of this particular design.

12 CHAIRMAN KRESS: Spoken like a good ex-  
13 V.P.

14 MR. LEITCH: Yeah, right.

15 MR. SIEBER: There was a discussion of the  
16 emergency power in the CD that was sent to us. There  
17 was a whole chapter on it.

18 CHAIRMAN KRESS: Yeah, that too was an  
19 attempt.

20 MR. LEITCH: Yeah, there were two  
21 sentences.

22 MR. SIEBER: Well, they got it.

23 MR. LEITCH: It said, "Do you need  
24 diesels?" But I mean, I don't know the capacity or  
25 the speed with which they are required, those kinds of

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1 issues.

2 MR. SIEBER: Maybe they don't know it  
3 either at this point.

4 MR. LEITCH: That's really all I had.

5 CHAIRMAN KRESS: Anybody else?

6 DR. RANSOM: Well, one observation that I  
7 had that's kind of off the wall probably, but this  
8 seemed to be the first CANDU 3 reactor that we've  
9 looked at that did not provided for making it very  
10 difficult to uncover the core. You know, even under  
11 accident situations the others seem to have designed  
12 features such that the containment was flooded to the  
13 point that the core could not be uncovered.

14 Now, it may be from a risk point of view  
15 there's nothing added by incorporating a feature like  
16 that, but it would be interesting to know why not.

17 CHAIRMAN KRESS: Anybody else?

18 Well, seeing as how you guys are obviating  
19 my comment about going around the table, I feel  
20 compelled to say some few things, too.

21 I do think it's a little early for us to  
22 make judgments on what the issues are now. That's why  
23 I did it this way, but I have a list of some of the  
24 issues I think might be important to resolve, and one  
25 on my list is the confirmation of the negative power

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1 core, including uncertainties.

2 I think there are some material issues  
3 that need to be addressed.

4 Well, at one time when we get to the  
5 severe accident part and the PRA part, I want to see  
6 more about the energetic fuel coolant interactions and  
7 the potential for propagation of a failure of one  
8 pressure tube to others.

9 I would like to see the termination of the  
10 amount of hydrogen produced during severe accidents  
11 compared to the capacity of the autocatalytic  
12 converters and/or the strength of the containment.

13 I think there was an issue dealing in  
14 Appendix K space with the thermal hydraulics code and  
15 what is the actual conservatism in the codes being  
16 used; what is the required conservatism, what are the  
17 margins and what are the figures of merit going to be?

18 I mean, is this going to be oxygen  
19 produced, hydrogen, or is it going to be heat clad  
20 temperature or departure from nuclear boiling water?  
21 I think the figures are going to be different because  
22 they relate specifically to U.S. reactors.

23 I'm looking forward to reviewing the core  
24 mount progression and source term. I think it's  
25 important for confirming the PRA results.

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1 I think very important, another important  
2 issue is the potential need for any additional  
3 integral and/or separate effects testing, and I don't  
4 think that's been resolved yet. That to me could be  
5 a potential showstopper if there's substantial needs  
6 there.

7 I think staff will have to give some sort  
8 of detailed review and acceptance, if that's the right  
9 word of the code kit that's being used by AECL. It  
10 doesn't look like a trivial ask if you're going to  
11 review all of those codes and pass judgment on them.

12 In terms of PRA, I think there is a  
13 question of quality and whether or not they ought to  
14 think about having an industry peer review pretty much  
15 like the ones in the U.S., and I'm particularly  
16 interested in how to deal with uncertainties in there,  
17 more than just parametric uncertainties. I want to  
18 see some discussion of what model uncertainties might  
19 do to you.

20 I think another issue for the staff is the  
21 set of design basis accidents that AECL has. Are they  
22 good enough? Are they equivalent to what we have in  
23 a sense, and is that good enough? And is there a dose  
24 acceptance criteria acceptable compared to what we  
25 have?

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1           And you know, I would like to see more  
2 thought given to their what I call frequency  
3 consequence acceptance curves. I think they look like  
4 very useful things. How do they compare with what we  
5 have in the U.S., and would they be useful for this  
6 last set of issues when we talked about needing  
7 acceptance criteria for limited core melt accidents  
8 and tritium release and other kinds of accidents that  
9 aren't full core melt.

10           That's kind of a set of issues. I don't  
11 see -- they're just things I'm interested in. I  
12 don't think they represent any shortcomings or  
13 anything. I don't want to give that impression.

14           So I think we'll hear more later, and I  
15 want to thank the staff once again and AECL people for  
16 a very informative discussion, even though we had to  
17 depart from the agenda a little bit. We'll have to  
18 make that up.

19           Yes, sir? Oh, that's a good question. If  
20 there are members of the public here that wish to make  
21 any comments, they're welcome to do so at this time.

22           Seeing none, I think at this time we will  
23 adjourn this meeting.

24           (Whereupon, at 6:06 p.m., the Advisory  
25 Committee meeting was adjourned.)

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Reactor Safeguards  
Future Plant Designs  
Subcommittee

Docket Number: n/a

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