

Official Transcript of Proceedings
NUCLEAR REGULATORY COMMISSION

Title: 10 CFR 2.206 Petition Review Board
RE: Vermont Yankee Nuclear Power Station
Mark Leye & Raymond Shadis on behalf of
the New England Coalition

Docket Number: 50-271

Location: (telephone conference)

Date: Monday, July 26, 2010

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Pages 1-39

Edited by John Boska, NRC Petition Manager

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
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10 CFR 2.206 PETITION REVIEW BOARD (PRB)
CONFERENCE CALL
RE
VERMONT YANKEE NUCLEAR POWER STATION
+ + + + +
MONDAY,
JULY 26, 2010
+ + + + +

The conference call was held at 2:03 p.m.,
Ted Quay, Chairman of the Petition Review Board,
presiding.

PETITIONERS: MARK LEYSE & RAYMOND SHADIS ON BEHALF OF
THE NEW ENGLAND COALITION

PETITION REVIEW BOARD MEMBERS:

TED QUAY, Deputy Director, Division of Policy and
Rulemaking, Office of Nuclear Reactor Regulation
(NRR)

JOHN BOSKA, Petition Manager for 2.206 petition,
Plant Licensing Branch 1-1, NRR

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PETITION REVIEW BOARD MEMBERS: (cont'd)

BRETT KLUKAN, Attorney, Office of General Counsel

TANYA MENSAH, Petition Coordinator, NRR

SHIH-LIANG WU, Nuclear Performance and Code Review

Branch, NRR

RICHARD DUDLEY, Rulemaking and International Projects

Branch, NRR

THOMAS SETZER, Senior Project Engineer, Division of

Reactor Projects, NRC Region I

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

(2:03 p.m.)

MR. BOSKA: I would like to thank everybody for attending this meeting.

My name is John Boska, and I'm the NRC's Petition Manager for this petition.

We are here today to allow the Petitioners, Mr. Leyse and Mr. Shadis, to address the Petition Review Board on behalf of the New England Coalition regarding their 2.206 petition dated June 7, 2010, on the fuel peak cladding temperature at the Vermont Yankee Nuclear Power Station, which is located near Brattleboro, Vermont.

I am the Petition Manager for the petition. The Petition Review Board Chairman is Ted Quay.

Mr. Leyse and Mr. Shadis made an initial presentation to the Petition Review Board, which we may also refer to as the PRB, on June 23, 2010. In a subsequent internal PRB meeting, the PRB's initial recommendation was to not accept this petition for review.

This meeting is scheduled to conclude by 3:00 p.m. The meeting is being recorded by the NRC Operations Center and will be transcribed by a Court

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1 Reporter. The transcript will become a supplement to
2 the petition. The transcript will also be made
3 publicly available.

4 I would like to open this meeting with
5 introductions. As we go around the room, please
6 clearly state your name, your position, and the office
7 that you work for within the NRC for the record.

8 I'm John Boska. I'm a Project Manager in
9 the Office of Nuclear Reactor Regulation, which is
10 also referred to as NRR.

11 CHAIRMAN QUAY: I'm Ted Quay. I'm the
12 Petition Review Board Chairman, and I'm also in NRR.

13 MR. WU: Shih-Liang Wu. I'm technical
14 staff working for NRR, in the Nuclear Performance and
15 Code Review Branch.

16 MR. DUDLEY: Richard Dudley. I'm in the
17 NRR Rulemaking Group.

18 MR. SLOAN: I'm Scott Sloan, NRR, as an
19 observer.

20 MS. POPOVA: I'm Alex Popova. I'm a
21 summer hire for the Division of Operating Reactor
22 Licensing, and I'm an observer.

23 MS. SALGADO: I'm Nancy Salgado. I'm a
24 Branch Chief in the Division of Operating Reactor
25 Licensing.

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1 MS. GIBSON: Lauren Gibson from the
2 Division of Operating Reactor Licensing as an
3 observer.

4 MS. INVERSO: I'm Tara Inverso from the
5 Division of Policy and Rulemaking as an observer.

6 MS. MENSAH: Tanya Mensah, the 2.206
7 Coordinator, Division of Policy and Rulemaking.

8 MR. KLUKAN: Brett Klukan, Office of
9 General Counsel.

10 MR. BOSKA: We have completed
11 introductions in the room here. At this time, are
12 there any other NRC participants from NRC headquarters
13 on the phone?

14 (No response.)

15 All right. Any NRC participants from the
16 NRC regional office on the phone?

17 MR. SETZER: Hi. This is Tom Setzer. I'm
18 a Senior Project Engineer from Region I.

19 MR. BOSKA: Are there any representatives
20 for the licensee on the phone?

21 (No response.)

22 Mr. Leyse, would you please introduce
23 yourself for the record?

24 MR. MARK LEYSE: Sure. Mark Leyse.

25 MR. BOSKA: And, Mr. Shadis, would you

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1 please introduce yourself for the record?

2 MR. SHADIS: Yes. This is Raymond Shadis,
3 last name S-H-A-D-I-S, for New England Coalition.

4 MR. BOSKA: Thank you.

5 MR. MARK LEYSE: And Mark Leyse speaking.
6 I believe Robert Leyse is going to also speak.

7 MR. ROBERT LEYSE: Correct.

8 MR. BOSKA: All right. We understand Mr.
9 Robert Leyse is also on the line.

10 MR. ROBERT LEYSE: Yes.

11 MR. BOSKA: Thank you. And we also
12 understand there are members of the public.

13 I would like to emphasize that we each
14 need to speak clearly and loudly to make sure that the
15 Court Reporter can accurately transcribe this meeting.

16 If you do have something that you would
17 like to say, please first state your name for the
18 record.

19 For those dialing into the meeting, please
20 remember to mute your phones to minimize any
21 background noise or distractions. If you don't have a
22 mute button, this can be done by pressing the keys
23 star 6. To unmute your phone, press the star 6 keys
24 again.

25 Please do not place this call on hold,

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1 since many phone systems play music when a call is on
2 hold, which is very annoying for the other callers.

3 Thank you.

4 At this time, I will turn it over to the
5 Petition Review Board Chairman, Ted Quay.

6 CHAIRMAN QUAY: Good afternoon. I'm Ted
7 Quay, the Petition Review Board Chairman. Welcome to
8 this meeting regarding the 2.206 petition submitted by
9 Mr. Leyse and Mr. Shadis.

10 I would like to first share some
11 background on our process. Section 2.206 of Title 10
12 of the Code of Federal Regulations describes the
13 petition process: the primary mechanism for the
14 public to request enforcement action by the NRC in a
15 public process. This process permits anyone to
16 petition the NRC to take enforcement-type related
17 action to NRC licensees or licensed activities.

18 Depending on the results of its
19 evaluation, the staff could modify, suspend, or revoke
20 an NRC-issued license, or take any other appropriate
21 enforcement action to resolve a problem. The NRC
22 staff's guidance for disposition of 2.206 petition
23 requests is in Management Directive 8.11, which is
24 publicly available.

25 The purpose of today's meeting is to give

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1 the Petitioners an opportunity to provide any
2 additional explanation or support for the petition.
3 The Petitioners have been advised that the Petition
4 Review Board's initial recommendation is to reject
5 this petition, as the PRB found no evidence that
6 Vermont Yankee was in violation of an NRC rule.

7 This petition describes what the
8 Petitioners believe are deficiencies in existing NRC
9 rules, and the PRB believes the proper process for it
10 is the rulemaking process.

11 This meeting is not a hearing, nor is it
12 an opportunity for the Petitioners to question or
13 examine the Petition Review Board on the merits or the
14 issues presented in the petition request. No decision
15 regarding the merits of this petition will be made at
16 this meeting.

17 Following this meeting, the Petition
18 Review Board will conduct its internal deliberations.
19 The outcome of this internal meeting will be
20 communicated to the Petitioners. The Petition Review
21 Board typically consists of a Chairman, usually a
22 manager at the Senior Executive Service level at the
23 NRC. It has a Petition Manager and a Petition Review
24 Board Coordinator. Other members of the Board are
25 determined by the NRC staff based on the content of

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1 the information in the petition request.

2 At this time, I would like to introduce
3 the Board. I'm Ted Quay, the Petition Review Board
4 Chairman. John Boska is the Petition Manager for the
5 petition under discussion today. Tanya Mensah is the
6 office Petition Review Board Coordinator.

7 Our technical staff includes Shih-Liang Wu
8 from NRR's Nuclear Performance and Code Review Branch;
9 Tom Setzer from NRC's Region I, Division of Reactor
10 Projects; and Richard Dudley from NRR's Rulemaking
11 Branch.

12 We also have legal advice from Brett
13 Klukan from the Office of General Counsel.

14 As described in our process, the NRC staff
15 will ask clarifying questions in order to better
16 understand the Petitioners' presentation and to reach
17 a reasoned decision whether to accept or reject the
18 Petitioners' request for review under the 2.206
19 process.

20 I would like to summarize the scope of the
21 petition under consideration and the NRC activities to
22 date. On June 7, 2010, Mr. Leyse and Mr. Shadis
23 submitted to the NRC a petition, ML Number 101610121,
24 under 10 CFR 2.206, regarding the fuel peak cladding
25 temperature at the Vermont Yankee Nuclear Power

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1 Station, which may also be referred to as VY.

2 Petitioners request that the NRC order the
3 licensee to lower the licensing basis peak cladding
4 temperature in order to provide a necessary margin of
5 safety. The Petitioners state that VY's licensing
6 basis for a peak cladding temperature of 1960 degrees
7 F does not provide a necessary margin of safety to
8 prevent fuel from melting in the event of a loss of
9 coolant accident, referred to as a LOCA, L-O-C-A.

10 The Petitioners state that data indicates
11 the licensing basis peak cladding temperature should
12 be lowered at least to 1832 degrees F, and possibly
13 lower. The Petitioners also state that, although
14 revisions to 10 CFR 50.46(b)(1) limit of 2200 degrees
15 F on peak cladding temperature has been proposed in a
16 rulemaking petition, this petition has been filed
17 separately under 2.206, because the concerns brought
18 forward are plant-specific and have immediate bearing
19 on safety margins at Vermont Yankee and require prompt
20 NRC review and action.

21 Allow me to discuss the NRC activities to
22 date. On or about June 7, 2010, the NRC received this
23 petition. On June 8th, this petition was assigned to
24 the NRC's Office of Nuclear Reactor Regulation for
25 evaluation. On June 23rd, the Petitioners

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1 participated in a teleconference with the Petition
2 Review Board. The transcript of that teleconference
3 is publicly available from the NRC's website under
4 ADAMS Accession Number ML101890014.

5 On July 8th, the Petition Manager informed
6 the Petitioners that the PRB's initial recommendation
7 was to reject this petition and offered the
8 opportunity for a meeting with the PRB. That led to
9 this teleconference.

10 As a reminder for our phone participants,
11 please identify yourself if you make any remarks, as
12 this will help in the preparation of the meeting
13 transcript that will be made publicly available.

14 Thank you.

15 Mr. Leyse and Mr. Shadis, I will turn this
16 over to you right now to allow you to provide any
17 information you believe the PRB should consider as
18 part of this petition, especially reasons why this
19 petition should be considered separately from the
20 petition for rulemaking.

21 Mr. Leyse and Mr. Shadis, you may now
22 proceed.

23 MR. SHADIS: Thank you. This is Raymond
24 Shadis. If I may, Mark, if it's good with you, I'll
25 lead off.

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1 MR. MARK LEYSE: Yes, I think that's a
2 good idea. Mark Leyse speaking. And then, my father
3 will -- Robert Leyse will follow you, and then I will
4 follow Robert Leyse.

5 MR. SHADIS: Thank you. I want first to
6 try to restate, in the plainest terms, what our
7 concern is. First, this petition is brought by New
8 England Coalition. New England Coalition is not a
9 party to any proceeding where this concern could be
10 admitted as part of the proceeding.

11 New England Coalition was not a party or a
12 commentator with respect to the rulemaking petition.
13 As we see it, we have no means of involving ourselves
14 in that petition. Therefore, as we see it, we have no
15 recourse other than the 2.206 process. This is our
16 only means of redress for what we see as a very
17 serious safety concern at Vermont Yankee Nuclear Power
18 Station.

19 Our concern, in simple terms, is that if
20 this particular plant, because of a loss of coolant
21 accident, should reach, exceed, or even approach the
22 licensing basis peak cladding temperature, there may
23 be at that point a chemical reaction initiated with
24 the fuel cladding that would greatly accelerate the
25 buildup of heat and temperature to the extent that

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1 there would be no credible means of recovery.

2 And with respect to Vermont Yankee in
3 particular, this is a powerplant where various
4 accident-mitigation-related components have been in
5 recent history shown to be inoperable at any given
6 point. We cannot ascertain how many such defects may
7 exist.

8 Our concern is that there should be no
9 allowance for any defects in accident mitigation
10 systems, and I would point in particular to the most
11 recent inspection report that we have in which the
12 high pressure coolant injection system was inoperable
13 for a period of time, and also in which safety-related
14 cables connected to the emergency diesel generators
15 were submerged, although they were not qualified for
16 wet conditions or submerged conditions.

17 The real questions here are the degree to
18 which the licensee would depend on any of these
19 systems when it comes to accident mitigation. We are
20 very concerned that the timeframe in which the
21 licensee has to act is very short, that the buildup of
22 temperature to peak cladding temperatures is a matter
23 of minutes, not hours, and that that time in which to
24 respond is shortened exponentially if you reach the
25 point at which the fuel cladding begins to rapidly

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1 oxidize.

2 So, you know, those variables, if you
3 will, can add up rather quickly to eliminate the
4 margin that has been allowed. Our position is that
5 for safety's sake the maximum margin obtainable for
6 the design peak cladding temperature and any likely
7 experienced peak cladding temperature has to be as
8 wide as it can be. And that is definitely not the
9 case at Vermont Yankee.

10 So, in short, it is New England Coalition
11 bringing this petition. We have no other recourse
12 that we can find within NRC regulation, other than the
13 2.206. And the issue is one of gravest, gravest
14 safety concern, and one of immediacy.

15 Thank you.

16 MR. BOSKA: Mr. Shadis, we have some
17 questions from the Petition Review Board for you.

18 MR. SHADIS: Thank you.

19 MR. KLUKAN: Mr. Shadis, this is Brett
20 Klukan. You say, Mr. Shadis, that New England
21 Coalition had no other recourse. Why couldn't New
22 England Coalition have submitted the 2.206 as a
23 petition for rulemaking?

24 MR. SHADIS: What forecloses that is the
25 fact that rulemaking is a process that generally takes

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1 a few years. It is --

2 MR. KLUKAN: I mean, that process is still
3 available to you.

4 MR. SHADIS: Well, the process is
5 available. One thing is that a rulemaking on the
6 generic question of peak cladding temperature is
7 already underway. It is -- as far as we can read the
8 regulation, we are precluded from filing a petition
9 for rulemaking on top of that petition for rulemaking.

10 But, in addition, it is simply
11 inappropriate because the rulemaking takes as long as
12 it does to address general issues, whereas in this
13 case there is the immediacy of the fact that VY is
14 being run at 120 percent of its original design
15 capacity, and the yield in fission products and the
16 resultant decay heat from that is greater, out of
17 proportion, than the original.

18 So, you know, this is -- again, this is
19 immediate, and it is particular to VY. So we don't
20 think -- our reading of it is that we can't enter into
21 a rulemaking, and, if we did, it would be not
22 productive, not appropriate, because of the timeframe
23 involved in getting NRC action.

24 MR. KLUKAN: Thanks. Two additional
25 questions. This is again Brett.

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1 MR. SHADIS: Sure.

2 MR. KLUKAN: So you are -- just to
3 understand why this is -- why you believe this is
4 distinct from the generic, is because of VY's history
5 of inoperable accident mitigation devices? Is that
6 what is different about it, that they have, in your
7 opinion, a poor history?

8 MR. SHADIS: Well, that is one factor, and
9 in that I -- you know, in my own inarticulate way, I
10 tried to point to the fact that if you have a very
11 small margin of safety between your design maximum
12 peak cladding temperature and what you may -- you
13 know, at what temperature you may actually get a rapid
14 oxidation reaction, then that small margin is
15 susceptible to any number of variables that you can
16 throw in. I mean, you may have an issue with failure
17 of a few control assemblies to insert.

18 And, you know, with Vermont Yankee there
19 is a concern for shadow corrosion that might distort
20 the channels and prevent that from happening. You
21 might have a question of blockage. With Vermont
22 Yankee, you have a steam hood, steam dryer, that has
23 got a number of cracks in it. And within the dynamics
24 of a loss of coolant accident, it might result in
25 loose parts that could cause blockage.

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1 What I'm saying is that those kinds of
2 considerations, plus the fact that there has been a
3 history of inoperability of various accident
4 mitigation systems, can add up to -- you know, those
5 variables can add up to effectively eliminate that
6 small margin. Our position is that that margin needs
7 to be expanded.

8 MR. KLUKAN: By "margin," do you mean the
9 temperature?

10 MR. SHADIS: Yes, the difference between
11 your license design peak cladding temperature and the
12 peak cladding temperature at which an exothermic
13 reaction may begin.

14 MR. MARK LEYSE: Mark Leyse. I just want
15 to state one thing. It would be the temperature where
16 there would be an exothermic reaction that would
17 begin, which would then -- the heat generated by that
18 reaction would in turn speed up the reaction rate,
19 which would in turn generate even more heat, so there
20 would be a loop and there would be runaway oxidation,
21 and that could perhaps, according to experimental
22 data, commence at 1832 degrees Fahrenheit roughly,
23 which is well below the current license basis peak
24 cladding temperature at Vermont Yankee.

25 Anyway, I'll turn it back to Ray. I just

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1 wanted to interject that.

2 MR. SHADIS: Thank you, Mark, for that
3 clarification.

4 MR. BOSKA: This is John Boska. There's
5 no further questions from the Petition Review Board,
6 so you may continue with the presentation.

7 MR. SHADIS: Well, I am, at least at this
8 point, unless there are some points to be clarified or
9 followed up on after Robert and Mark Leyse present, I
10 am done for the time being. So I will just step
11 aside, and I think Robert Leyse is next as far as I
12 recall.

13 MR. ROBERT LEYSE: Okay. Thank you. This
14 is Robert Leyse, and I want to thank John Boska for
15 getting my two slides to the Petition Review Board. I
16 will read these.

17 Slide 1 of 2, preventing thermal runaway.

18 It is disturbing that the Petition Review Board
19 reports, "There was considerable technical review
20 involved in the selection of 2200 degrees, and it will
21 involve considerable technical review to reach a
22 decision on PRM 50-93, and decide if that number
23 should be revised."

24 This 2.206 petition calls for prompt
25 action independent of PRM 50-93. It is a fact that

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1 the considerable technical review involved in the
2 selection of 2200 degrees was focused on embrittlement
3 criteria, not thermal runaway.

4 There is no need for considerable
5 technical review and further delays to confirm that
6 2200 degrees is non-conservative. The evidence is
7 complete. NRC has apparently never studied Baker-
8 Just, ML050550198, and until recently it did not even
9 have copies of the key references.

10 Figure 16 is copied from page 37 of the
11 Baker-Just report. And for the record, it shows the
12 effects of temperature on the zirconium-water
13 reaction. It lists data points by three separate
14 investigators. However, only the Lemmon data includes
15 the temperature region that is really pertinent to
16 what we are talking about.

17 That is, the Lemmon data covers a pretty
18 wide range, but it is the only investigator who covers
19 from 1000 Centigrade up to a little over 1200
20 Centigrade, which is, in my opinion, the region of
21 interest.

22 So slide 2 of 2, preventing thermal
23 runaway. The Lemmon report, ML100570218, was not
24 acquired by the NRC until April 2010. Figure C1 is
25 from page C4, and the adjacent figure is excerpted

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1 from the flow sheet, Figure C3 on page C5. Note the
2 Figure C1, the Zircaloy-2 specimen, two inches long,
3 half-inch in diameter, with a hole roughly half the
4 length for a thermocouple installation.

5 To the right you see the excerpted figure,
6 which shows the specimen in place within a Vycor tube,
7 which isn't labeled as such, with an induction coil
8 around it.

9 THE COURT REPORTER: This is the Court
10 Reporter. We're getting audio interference that is
11 going to make transcribing this portion difficult, if
12 not impossible. If you are not speaking, if you could
13 mute your phone, we would appreciate it.

14 MR. ROBERT LEYSE: I don't believe I am
15 causing it. This is Robert Leyse.

16 Okay. I will proceed. Anyway, getting
17 back to the slide, Lemmon induction heated a
18 Zircaloy-2 cylinder two inches long by a half-inch in
19 diameter, as illustrated in the above figures.

20 So now I'll read the last paragraph of
21 that slide. "It is absurd to license the emergency
22 cooling of tons of zirconium alloy with thousands of
23 square feet of interfacial surface area based on the
24 limited investigations that yielded the Baker-Just
25 equation. Despite this, Appendix K to Part 50, ECCS

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1 Evaluation Models, Item 5, specifies that the rate of
2 energy release from the metal/water reaction shall be
3 calculated using the Baker-Just equation and
4 Number 50.46, Acceptance Criteria, Item (b)(1),
5 specifies the 2200 degrees. Moreover, this 2.206
6 petition presents data from multi-rod (assembly)
7 severe fuel damage experiments, for example, the LOFT
8 LP-FP2 experiment, that show that the Baker-Just
9 equation is non-conservative for calculating the
10 temperature at which thermal runaway would occur in
11 the event of a LOCA."

12 So, moving on beyond these slides, you
13 might ask the question: well, how did all of this
14 fall through the cracks? From the NRC's website I
15 read some history, in part labeled AEC to NRC, and I
16 quote, "By 1974, the AEC's regulatory programs had
17 come under such strong attack that Congress decided to
18 abolish the agency. Supporters and critics of nuclear
19 power agreed that the promotional and regulatory
20 duties of the AEC should be assigned to different
21 agencies." And, thus, NRC began operations in January
22 1975.

23 So let's trace a little bit of the history
24 of Baker-Just. All this came about under the old AEC.
25 The Baker-Just equation came out in May 1962, some 13

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1 years before the NRC came online.

2 Now, regarding the reports that NRC didn't
3 have until recently, there is the Bostrom report,
4 which came out of the old Naval Reactors Division,
5 Rickover material. In that case, they induction
6 heated a Zircaloy cylinder a half-inch long by a
7 little over a half-inch in diameter with an internal
8 diameter a little over a quarter of an inch.

9 And then, Lemmon came along three years
10 later and did the test that I have referred to with a
11 two-inch long rod.

12 Incidentally, the Bostrom report, the
13 WAPD-104, the one with the cylinder a half-inch long,
14 goes back 21 years before the NRC came in. That was
15 1954, I believe. Then, Lemmon's came in in 1957. Yet
16 the NRC had never looked at this, even though one of
17 the reasons why the NRC was set up was because
18 apparently people felt this wasn't covered adequately.

19 So, anyway, I just want to finish. This
20 2.206 petition on Vermont Yankee clearly establishes
21 that Vermont Yankee's licensing basis PCT of 1960
22 degrees F is not low enough to protect public health
23 and safety. The PRB is urged to accept this petition
24 for prompt review.

25 So I am finished. So the next speaker may

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1 proceed.

2 MR. MARK LEYSE: Yes. Mark Leyse
3 speaking. I just want to add that Robert Leyse has
4 conducted experiments with both single rod,
5 inductively heated tests of Zircaloy, and also multi-
6 rod bundle tests. So he has a lot of experience in
7 this area with Zircaloy.

8 Anyway, yes, Mark Leyse speaking, and I
9 will now begin. I sent some information to John Boska
10 last night, and I'm wondering, were you able to print
11 out those pages and provide them to the Petition
12 Review Board?

13 MR. BOSKA: This is John Boska. We did
14 get the pages from the Three Mile Island accident
15 slides, and the Petition Review Board does have a
16 copy.

17 MR. MARK LEYSE: Oh, thank you very much.
18 Yes, I want to begin just by talking about that, and
19 then I will talk about your initial decision and e-
20 mail that I received from you on July 8th.

21 But basically I find it very compelling
22 that in a presentation at the American Nuclear
23 Society, and the European Nuclear Society's 2007
24 international meeting, the title of that was "Making
25 the Renaissance Real", that Robert E. Henry, who is

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1 the Senior Vice President of Fauske and Associates, he
2 delivered a presentation titled TMI-2: A Textbook in
3 Severe Accident Management.

4 And basically he stated that thermal
5 runaway due to the exothermic oxidation of Zircaloy
6 commenced at 1000 degrees Celsius during the Three
7 Mile Island Unit 2 accident in 1979. So that would be
8 commenced at 1832 degrees Fahrenheit.

9 Basically, one of the slides --
10 unfortunately, they are not numbered, but it should --
11 it was page 130 of the presentation, so I think it
12 will be your seventh page. Basically, there are three
13 bullet points, and I will just read the last two. The
14 title of the slide is "Fuel Cladding Oxidation," and
15 he said, "Increasing temperatures caused the Zircaloy
16 oxidation rate to increase, which was accompanied by
17 an increased release rate of chemical energy."

18 Then, the third point is, "At about 1000
19 degrees Celsius, the oxidation energy release rate
20 equaled the decay power." From that point on, the
21 core was in a thermal-runaway state.

22 Now, I want to point out that when he says
23 that this was initiated at 1000 degrees Celsius -- so
24 that's 1832 degrees Fahrenheit -- this is speculation,
25 because there was no thermocouple data, unfortunately,

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1 that could confirm this. But it is very compelling
2 that he would state that, and he obviously has a lot
3 of experience in the -- I'm sorry, there was some
4 interference.

5 Yes. So I find it very compelling that he
6 would claim or state that thermal runaway commenced at
7 1000 degrees Celsius during the Three Mile Island
8 Unit 2 accident. And he did present this at the
9 American Nuclear Society meeting and European Nuclear
10 Society 2007 international meeting.

11 And then, what is interesting is that in a
12 slide that was on page 50 -- and this should be the
13 sixth page that you have -- it has a title "Example:
14 Core Heat Uprate, Escalation Due to Cladding
15 Oxidation." And the bullet point is:

16 Important tests:

17 Out-of-Reactor - CORA;

18 In-Reactor - SFD, (I believe that would be for the
19 power burst facility severe fuel damage experiments),
20 FLHT, then, he states, "LOFT-FP2," meaning LOFT
21 LP/FP2, and PHEBUS.

22 Now, I have mentioned all of these
23 experiments in the Vermont Yankee petition, the 2.206
24 petition, except the SFD experiments. I did not
25 mention those. But I relied very heavily on the CORA

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1 experiments and the LOFT, the final LOFT experiment.

2 So here there is a presentation at an ANS
3 meeting, and he is stating that these are very
4 important experiments regarding the oxidation rates
5 during an accident, and that they are very important
6 for the core heatup rate and the escalation --
7 temperature escalation that would be due to oxidation.

8 So now I just want to move on, having said
9 that, to the letter that I received, the e-mail I
10 received, on July 8th from John Boska. And, first, I
11 want to thank you for forwarding the material
12 regarding the reaction between boron carbide and
13 stainless steel that is in the control blades,
14 forwarding that to Rulemaking Branch.

15 But I do want to address an important
16 issue. In the e-mail you state that -- and you have
17 stated so earlier in this meeting, that the Petition
18 Review Board finds no evidence that Vermont Yankee is
19 in violation of 10 CFR 50.46.

20 Now, that would be regarding peak cladding
21 temperature, and that would be the 2200 limit that
22 that rule stipulates.

23 Now, I don't see how you could come up
24 with a statement like that -- that the petition
25 presents no evidence, because I think the evidence is

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1 rather strongly discussed in the petition, and there
2 is a lot of experimental data that I reference in the
3 petition -- the same experimental data from the same
4 experiments that were cited by Robert E. Henry at the
5 ANS meeting in 2007 as being very important regarding
6 temperature escalations that can occur during a severe
7 accident due to oxidation rates.

8 So, in the 2.206 petition I have discussed
9 experimental data from the CORA experiments in which
10 runaway oxidation commenced at 1000 degrees Celsius,
11 1832 degrees Fahrenheit, and the local cladding
12 temperature increased at that point by tens of degrees
13 Fahrenheit per second.

14 So within a period less than 30 seconds
15 the cladding temperature would have exceeded 2200
16 degrees Fahrenheit, the regulated limit. So Vermont
17 Yankee's licensing basis peak cladding temperature
18 right now is 1960 degrees Fahrenheit, and that is
19 indeed below 2200 degrees Fahrenheit.

20 However, there is experimental data just
21 cited, and also cited by Robert E. Henry in his
22 presentation, that in the event that the cladding
23 could reach 1832 degrees Fahrenheit, more than 100
24 degrees Fahrenheit below the licensing basis peak
25 cladding temperature of Vermont Yankee, within 30 or

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1 so seconds it would be over 2200 degrees Fahrenheit,
2 thus 10 CFR 50.46 would be violated.

3 And what would happen is it would just
4 continue rapidly increasing in a local area, and it
5 would get up to around 3300 degrees Fahrenheit in less
6 than a minute, or less than two minutes to be
7 conservative, and at that point, in that local area,
8 the Zircaloy would start to melt and that would be
9 what would lead to a partial meltdown or a complete
10 meltdown.

11 So now I just want to ask you a couple of
12 questions regarding your statement. And, again, it is
13 a very strong statement: "I think that there is no
14 evidence presented in the petition." Could you please
15 explain that, the statement that there is no evidence?
16 I mean, does the Petition Review Board believe that
17 the experimental data that was cited in the papers
18 discussed in the petition, that that is incorrect?

19 MR. KLUKAN: Mr. Leyse, this is Brett
20 Klukan. I think you already hit the nail on the head.
21 You stated that VY, as their license dictates, has a
22 peak cladding temperature of some 1900 degrees, which
23 is below the 2200 that is dictated by the rule. And
24 they are in compliance with the rule, and you provide
25 no evidence to the contrary.

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1 What you would then do, to which the PRB
2 is not taking a position on at this point, is whether
3 that 2200 number is correct given the data you present
4 in the experiment. Those are two separate issues.

5 Whether VY is currently in compliance with
6 the rule as written, and whether the rule should be
7 changed as you contend, or as my understanding of what
8 your contention is, is that the rule is incorrect in
9 setting that limit, are two separate questions. You
10 yourself have conceded that VY is in compliance with
11 50.46 as the peak cladding temperature, as written.

12 MR. MARK LEYSE: Yes, I would like to
13 respond. I think I have just demonstrated -- and, as
14 I say, the experimental data cited in the petition
15 illustrates that it is possible that if the cladding
16 would reach 1832 degrees Fahrenheit, basically within
17 60 or so seconds, maybe a little longer, it is going
18 to be up around 3300 degrees Fahrenheit.

19 So basically your limit might as well, you
20 know, be the 3300. I mean, what is the point? You
21 are going to just delay this for another 60 seconds.
22 That is the margin of safety that you have.

23 I think that you are correct, 1960 degrees
24 Fahrenheit is below 2200, but my point is, if you get
25 to 1832, you are going to get up well past 2200 within

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1 about 60 seconds. So I think that demonstrates --
2 now, this is experimental data, that that demonstrates
3 that actually, 1960 degrees Fahrenheit really is not a
4 margin of safety, and it demonstrates that Vermont
5 Yankee is actually not in compliance with 10 CFR
6 50.46. I mean, that is if you believe the
7 experimental data that I cited in the petition.

8 MR. KLUKAN: Again, Mr. Leyse, this is
9 Brett Klukan. The PRB is not necessarily taking a
10 position on your arguments regarding what the number
11 should be. Quite frankly, it means that you believe,
12 or my understanding of your contention is is that the
13 number, as set out in the rule, the 2200, is incorrect
14 due to these experiments you brought forward, which
15 show that the number should be lower.

16 The PRB is not taking necessarily a final
17 position on that -- is not taking a final position on
18 that statement, and the factual evidence you bring in
19 support of that statement. The only thing we stated
20 was that, as written, VY is in compliance with 50.46.

21 Do you believe that there is some other
22 enforcement concern here? What I'm trying to get at,
23 how, then, would your contention not simply be solved
24 -- or not simply, but be solved by a petition for
25 rulemaking to change 50.46?

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1 MR. MARK LEYSE: If you were able to
2 facilitate that and get it done as rapidly as the
3 Petition Review Board could mend the problem at
4 Vermont Yankee, that would be fine. But I actually
5 submitted another petition, which is actually being
6 considered in the rulemaking process, and I am very
7 well aware that it takes at least a few years, perhaps
8 even longer than that. It is still not finished.
9 This is something I submitted back in 2007.

10 I'm also aware of other petitions for
11 rulemaking that were submitted regarding the metal-
12 water reaction rate. One I can think of was submitted
13 back in 2002. That would be PRM 50-76 that was
14 submitted by Robert Leyse. That took until 2005 for
15 the NRC to actually reject it, and that was without
16 even consulting the reports that Robert Leyse just
17 mentioned earlier when he was speaking -- the Bostrom
18 report, the Lemmon report, inductively-heated
19 specimens that are about two inches long, when you are
20 actually licensing tens of thousands of square feet of
21 interfacial fuel rods -- I mean, there are tens of
22 thousands of fuel rods in a core, so that's why you
23 would get a different reaction rate.

24 Anyway, I guess I'm kind of going off on a
25 tangent, but I'm very well aware of how long the

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1 petition review process can take. And I think that
2 this is a very serious issue. We are talking about if
3 you have a loss of coolant accident at this aging
4 plant -- Ray Shadis has discussed some of the problems
5 at Vermont Yankee.

6 If you have such an accident, and the
7 temperature of the fuel rods gets up to 1832 degrees
8 Fahrenheit, based on experimental data you may have a
9 partial or a complete meltdown. I think that's
10 something that is a very serious issue, and obviously
11 the rulemaking process could solve this problem, but
12 it may take too long. It could take decades.

13 I mean, believe it or not, this very same
14 issue -- thermal runaway -- that was brought up by
15 Union of Concerned Scientists in the Atomic Energy
16 Commission rulemaking hearings in the early '70s, and
17 they presented data from a Zircaloy experiment multi-
18 rod test that was conducted by General Electric.

19 And someone -- Roger Griebe from Aerojet,
20 he was the contractor for the Atomic Energy
21 Commission, and he basically largely agreed with the
22 point of Union of Concerned Scientists on this. There
23 was a situation where a bundle of fuel rods had
24 thermal runaway, and it commenced, according to plots
25 of the temperature data, below 2200 degrees

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1 Fahrenheit. And they brought that up during the
2 rulemaking hearings in the early '70s. I mean, this
3 has been going on for decades. There is a paper trail
4 on this.

5 And you are not doing anything about this,
6 and this is -- you are a regulator. You are supposed
7 to look out for the public safety. This is a very
8 serious issue. So I think that is just really
9 something that, you know, I have presented
10 experimental data on the Baker-Just equation, which is
11 what you used -- what Vermont Yankee used to set their
12 licensing basis PCT, that is based off of experimental
13 data also.

14 What do you think? Do you really think
15 that a piece of two-inch long cladding, a small little
16 specimen, do you really believe that that data is
17 superior to data from multi-rod experiments regarding
18 the reaction rate? I mean, I think this is a very
19 serious issue that I think you should just take into
20 consideration, you know, immediately.

21 MR. KLUKAN: Mr. Leyse, this is Brett
22 Klukan again. By no means does the PRB -- the PRB
23 takes your concerns with all due seriousness, as the
24 NRC does all concerns raised by the public
25 regarding --

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1 THE COURT REPORTER: This is the Court
2 Reporter. I cannot pick up Mr. Klukan's comments.

3 MR. KLUKAN: I'll start again. This is
4 Brett Klukan. Mr. Leyse, by no means is the PRB
5 discounting the seriousness of the concerns you are
6 raising. We treat all concerns raised by the public
7 with due seriousness regarding the safety of our
8 regulated facilities.

9 One additional question I have, and I'm
10 trying to wrap my mind around still, is why is it not
11 a generic issue to all reactors, or the majority of
12 reactors in the United States? Why is it simply about
13 VY?

14 MR. MARK LEYSE: Well, I would agree with
15 you what I'm talking about right now regarding the
16 metal-water reaction rate, it most certainly is a
17 generic issue. So I am not going to say that that is
18 only pertinent to Vermont Yankee. It is definitely an
19 issue that affects all nuclear powerplants that are
20 licensed in the United States, as you stated, as John
21 Boska stated in his e-mail of July 8th. I do not see
22 that as being a real reason for not taking this into
23 consideration regarding Vermont Yankee, regarding
24 particular problems at Vermont Yankee that Ray Shadis
25 has discussed in this meeting and in our previous

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1 meeting.

2 And I think what I'm trying to impress
3 upon you is just that this is a very serious issue.
4 It's a very serious safety issue, and it is something
5 that the rulemaking process could take far too long to
6 address properly.

7 I would hope that the rulemaking process
8 in this case would be expedited, but --

9 MR. SHADIS: Okay. May I add on?

10 MR. MARK LEYSE: Most certainly.

11 MR. SHADIS: Thank you. We have just a
12 few minutes in the allotted time. With respect to the
13 violation of a particular part of 10 CFR Part 50, I
14 would refer you -- as the Section 2.206 refers you
15 back to Section 2.202, that what is required here is
16 that there be alleged violations or, it says,
17 potentially hazardous conditions and other facts
18 deemed sufficient grounds for the proposed action.

19 So, you know, I don't know how you all
20 want to look at it. We're not attorneys, and we are
21 also not specifically grounded in NRC regulation. You
22 know, this could be proceeding under an unanalyzed
23 condition. The question really here is a question of
24 safety margin.

25 And with respect to the specificity of

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1 Vermont Yankee, this petition is brought by New
2 England Coalition, which is headquartered within the
3 emergency planning zone. Our constituents live there.
4 They are affected directly by Vermont Yankee. This
5 particular plant has conditions that are similar to
6 many other plants, but not in combination.

7 This is a plant which took a 20 percent
8 power uprate in one step, the first one to do so. It
9 is a plant nearing the end of its original license
10 term. It is a plant with a history of maintenance
11 failures, management failures, and, in particular,
12 directed to, you know, the accident mitigation
13 systems.

14 I think that we are asking, really, NRC to
15 take a look at this plant in total to -- and I guess
16 also, I might mention, that there have been a number
17 of design basis issues that have emerged over time,
18 including some things that are actions to be taken in
19 response to an onset of an accident.

20 So, you know, it is Vermont Yankee in
21 particular, in combination with all of the defects
22 that it has exhibited over time, and the extra stress
23 -- the extra heat load of extended power uprate, and
24 the fact that the Petitioner is affected by Vermont
25 Yankee.

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1 We have no knowledge of what conditions
2 may be at other plants. We have not reviewed any
3 other plants' peak cladding temperature analysis.
4 What we have is information from Vermont Yankee, and
5 we are bringing this petition directly on that basis.

6 So, please, go back and, -- NRC is
7 entitled here to take, you know, action within its
8 discretion. And the bottom line is assuring public
9 health and safety, and to do that one has to establish
10 reasonable margins at every level. So that is our
11 position in the short.

12 Thank you.

13 CHAIRMAN QUAY: Okay. At this time, does
14 the staff here at headquarters have any questions for
15 Mr. Leyse or Mr. Shadis?

16 (No response.)

17 Seeing none, what about the region?

18 MR. SETZER: No questions. Thank you.

19 CHAIRMAN QUAY: Okay. Before we conclude
20 the meeting, members of the public may ask questions
21 about the NRC process for 2.206 petitions. However,
22 as stated at the opening, the purpose of this meeting
23 is not to provide an opportunity for the public to
24 question or examine the Petition Review Board
25 regarding the merits of the petition request. Do any

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1 members of the public have any questions?

2 (No response.)

3 Okay. Mr. Leyse and Mr. Shadis, thank you
4 for taking time to provide the NRC staff with
5 clarifying information on the petition you have
6 submitted.

7 Before we close, does the Court Reporter
8 need any additional information for the meeting
9 transcript?

10 THE COURT REPORTER: This is the Court
11 Reporter on the line now. I will have to go back and
12 relisten to portions. Is there a specific person on
13 staff, if I have technical questions, that I should
14 call? I don't know at this point if Google is going
15 to provide me with the answers to questions I will
16 develop.

17 CHAIRMAN QUAY: Yes. You could consult
18 with John Boska.

19 MR. BOSKA: My phone number is 301-415-
20 2901.

21 THE COURT REPORTER: 2901. Thank you. If
22 I have those, I expect I will develop them within the
23 hour.

24 CHAIRMAN QUAY: Thank you.

25 THE COURT REPORTER: Thank you.

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1 CHAIRMAN QUAY: With that, this meeting is
2 concluded, and we will be terminating the phone call.

3 MR. MARK LEYSE: Mark Leyse. I just
4 wanted to thank the Petition Review Board, and thank
5 John Boska for providing those slides.

6 MR. SHADIS: Ray Shadis here, and I will
7 second that. Thank you so much.

8 CHAIRMAN QUAY: You're welcome. Thank
9 you.

10 (Whereupon, at 3:05 p.m., the proceedings in the
11 foregoing matter were adjourned.)

12
13 Attachment 1: Two slides on Preventing Thermal
14 Runaway, discussed by Robert Leyse.

15 Attachment 2: Seven slides from a TMI-2 workshop by
16 Robert Henry, discussed by Mark Leyse.

17
18
19

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Leyse/Shadis 2.206 petition G20100368, Vermont Yankee PCT
Slide 1 of 2 PREVENTING THERMAL RUNAWAY

It is disturbing that the Petition Review Board reports: *There was considerable technical review involved in the selection of 2200 degrees, and it will involve considerable technical review to reach a decision on PRM 50-93, and decide if that number should be revised.*

This 2.206 Petition calls for prompt action independent of PRM-50-93.

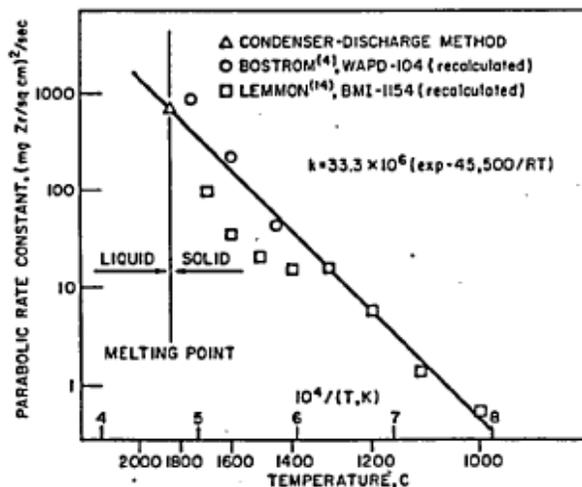
It is a fact that the considerable technical review involved in the selection of 2200 degrees was focused on embrittlement criteria, not thermal runaway.

There is no need for considerable technical review and further delays to confirm that 2200 degrees is non-conservative. The evidence is complete.

NRC has apparently never studied Baker-Just (ML050550198) and until recently it did not even have copies of the key references.

Figure 16 is copied from page 37 of the Baker-Just report:

Figure 16
EFFECT OF TEMPERATURE ON THE
ZIRCONIUM-WATER REACTION



Only the Lemmon data includes the pertinent temperature region.

Slide 2 of 2 PREVENTING THERMAL RUNAWAY

The Lemmon report, ML100570218, was not acquired by NRC until April, 2010. Figure C-1 is from page C-4 and the adjacent figure is excerpted from the flow sheet, Figure C-3 on page C-5.

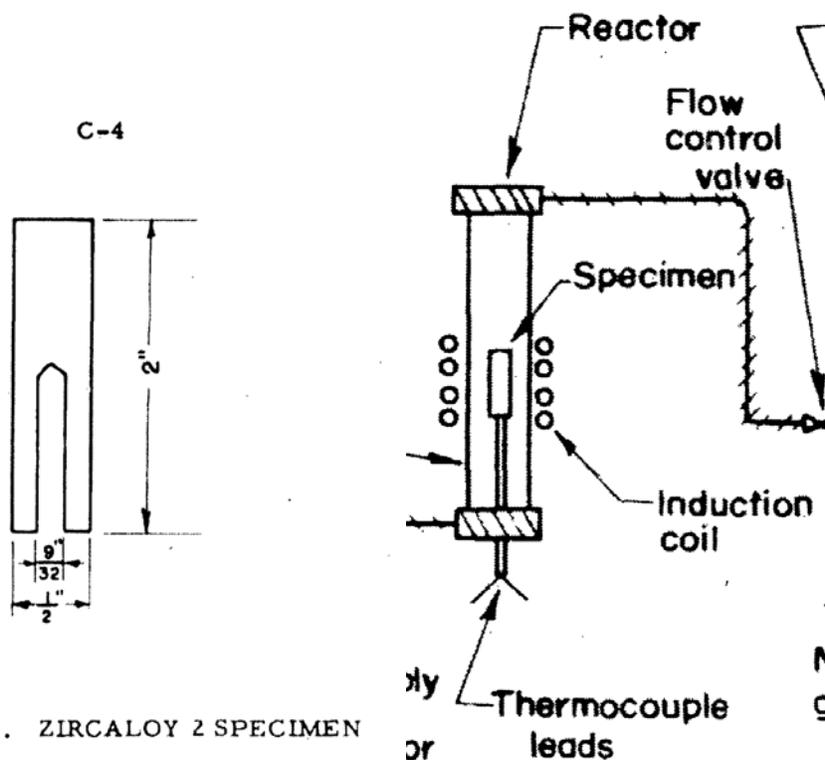


FIGURE C-1. ZIRCALOY 2 SPECIMEN

Lemmon induction heated a zircaloy-2 cylinder, 2 inches long by 0.5 inches in diameter, as illustrated in the above figures.

It is absurd to license the emergency cooling of tons of zirconium alloy with thousands of square feet of interfacial surface area based on the limited investigations that yielded the Baker-Just equation. Despite this, Appendix K to Part 50--ECCS Evaluation Models, Item 5, specifies that the rate of energy release from the metal/water reaction shall be calculated using the Baker-Just equation and § 50.46 Acceptance Criteria, item (b)(1) specifies the 2200 degrees. Moreover, this 2.206 Petition presents data from multi-rod (assembly) severe fuel damage experiments (e.g., the LOFT LP-FP-2 experiment) that show the Baker-Just equation is non-conservative for calculating the temperature at which thermal runaway would occur in the event of a LOCA.

TMI-2: A Textbook in Severe Accident Management

R. E. Henry
NISD Professional Development
Workshop

2007 ANS/ENS International Meeting

November 11, 2007

Acknowledgments

- Dana Powers for sending me the slides he has used in lectures on the TMI-2 accident.
- Hans Fauske for looking over all of the slides we are using today.

What are the Key Accident Management Insights to be Discussed

- Timing of the coolant inventory loss and the core overheating
- Rapidity of the core damage once the fuel cladding oxidation begins
- Available fission barriers
- Available debris barriers
- Cooling of a compacted core
- Ultimate cooling of the debris
- Hydrogen Generation and Combustion

TMI-2: What Happened on March 28, 1979?

- Due to a lack of makeup/injection, the reactor core was starved of water, i.e. the core was eventually uncovered.
- As a result of decay power the core was overheated sufficiently that a significant oxidation reaction occurred between the Zircaloy fuel cladding and steam in the core.
- The chemical energy release caused the core to overheat faster and eventually melt or liquefy the individual constituents.
- Most of the molten core material eventually relocated outside of the original core boundaries.
- The core material was eventually quenched by water in the Reactor Pressure Vessel (RPV).

Fuel Cladding Oxidation

- The Zr in the Zircaloy cladding will oxidize in a high temperature steam environment: hydrogen and energy (heat) are released by this reaction



The heat of reaction, ΔH_{R} , is about 6.5 MJ/kg.

- At about 1000 C, the rate of chemical energy release approximately equals the decay power.
- The oxidation rate increases with increasing temperature, which leads to an escalating core heatup rate.
- Therefore, the core damage was generally caused by the cladding oxidation.

Example: Core Heatup Rate Escalation Due to Cladding Oxidation

- Important Tests

Out-of-Reactor – CORA

In-Reactor SFD, FLHT, LOFT-FP2 and PHEBUS

Fuel Cladding Oxidation

- As the boil-off of the water in the core continued, the uncovered region continued to heatup with the highest cladding/fuel temperatures being at about the $\frac{3}{4}$ core height location.
- Increasing temperatures caused the Zircaloy oxidation rate to increase which was accompanied by an increased release rate of chemical energy.
- At about 1000 C, the oxidation energy release rate equaled the decay power. From this point on, the core was in a thermal-runaway state. During this interval the Zircaloy reaction was limited by the rate of steam generated in the covered part of the core which decreased as the water level decreased.