Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

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

Docket Number: 50-271

Location: (telephone conference)

Date: Monday, July 26, 2010

Work Order No.: NRC-371 Pages 1-39

Edited by John Boska, NRC Petition Manager

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(No response.)

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

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

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

(No response.)

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

MR. MARK LEYSE: Sure. Mark Leyse.

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

please introduce yourself for the record?

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

MR. BOSKA: Thank you.

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

MR. ROBERT LEYSE: Correct.

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

MR. ROBERT LEYSE: Yes.

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

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

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

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

Please do not place this call on hold,

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

Thank you.

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

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

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

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

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

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

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

Following this meeting, the Petition Review Board will conduct its internal deliberations. The outcome of this internal meeting will be communicated to the Petitioners. The Petition Review Board typically consists of a Chairman, usually a manager at the Senior Executive Service level at the NRC. It has a Petition Manager and a Petition Review Board Coordinator. Other members of the Board are determined by the NRC staff based on the content of the information in the petition request.

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

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

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

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

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

Station, which may also be referred to as VY.

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

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

Allow me to discuss the NRC activities to date. On or about June 7, 2010, the NRC received this petition. On June 8th, this petition was assigned to the NRC's Office of Nuclear Reactor Regulation for evaluation. On June 23rd, the Petitioners participated in a teleconference with the Petition Review Board. The transcript of that teleconference is publicly available from the NRC's website under ADAMS Accession Number ML101890014.

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

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

Thank you.

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

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

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

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

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

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

Our concern, in simple terms, is that if this particular plant, because of a loss of coolant accident, should reach, exceed, or even approach the licensing basis peak cladding temperature, there may be at that point a chemical reaction initiated with the fuel cladding that would greatly accelerate the buildup of heat and temperature to the extent that there would be no credible means of recovery.

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

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

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

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

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

Thank you.

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

MR. SHADIS: Thank you.

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

MR. SHADIS: What forecloses that is the fact that rulemaking is a process that generally takes a few years. It is --

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

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

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

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

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

MR. SHADIS: Sure.

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

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

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

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

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

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

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

Anyway, I'll turn it back to Ray. I just wanted to interject that.

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

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

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

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

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. And for the record, it shows the effects of temperature on the zirconium-water reaction. It lists data points by three separate investigators. However, only the Lemmon data includes the temperature region that is really pertinent to what we are talking about.

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

So slide 2 of 2, preventing thermal runaway. The Lemmon report, ML100570218, was not acquired by the NRC until April 2010. Figure C1 is from page C4, and the adjacent figure is excerpted from the flow sheet, Figure C3 on page C5. Note the Figure C1, the Zircaloy-2 specimen, two inches long, half-inch in diameter, with a hole roughly half the length for a thermocouple installation.

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

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

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

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

So now I'll read the last paragraph of that slide. “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 Number 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, for example, the LOFT LP-FP2 experiment, that show that the Baker-Just equation is non-conservative for calculating the temperature at which thermal runaway would occur in the event of a LOCA."

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

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

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

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

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

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

So I am finished. So the next speaker may proceed.

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

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

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

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

But basically I find it very compelling that in a presentation at the American Nuclear Society, and the European Nuclear Society's 2007 international meeting, the title of that was “Making the Renaissance Real”, that Robert E. Henry, who is the Senior Vice President of Fauske and Associates, he delivered a presentation titled TMI-2: A Textbook in Severe Accident Management.

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

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

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

Now, I want to point out that when he says that this was initiated at 1000 degrees Celsius -- so that's 1832 degrees Fahrenheit -- this is speculation, because there was no thermocouple data, unfortunately, that could confirm this. But it is very compelling that he would state that, and he obviously has a lot of experience in the -- I'm sorry, there was some interference.

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

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

Important tests:

Out-of-Reactor - CORA;

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

Now, I have mentioned all of these experiments in the Vermont Yankee petition, the 2.206 petition, except the SFD experiments. I did not mention those. But I relied very heavily on the CORA experiments and the LOFT, the final LOFT experiment.

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

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

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

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

Now, I don't see how you could come up with a statement like that -- that the petition presents no evidence, because I think the evidence is rather strongly discussed in the petition, and there is a lot of experimental data that I reference in the petition -- the same experimental data from the same experiments that were cited by Robert E. Henry at the ANS meeting in 2007 as being very important regarding temperature escalations that can occur during a severe accident due to oxidation rates.

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

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

However, there is experimental data just cited, and also cited by Robert E. Henry in his presentation, that in the event that the cladding could reach 1832 degrees Fahrenheit, more than 100 degrees Fahrenheit below the licensing basis peak cladding temperature of Vermont Yankee, within 30 or so seconds it would be over 2200 degrees Fahrenheit, thus 10 CFR 50.46 would be violated.

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

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

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

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

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

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

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

I think that you are correct, 1960 degrees Fahrenheit is below 2200, but my point is, if you get to 1832, you are going to get up well past 2200 within about 60 seconds. So I think that demonstrates -- now, this is experimental data, that that demonstrates that actually, 1960 degrees Fahrenheit really is not a margin of safety, and it demonstrates that Vermont Yankee is actually not in compliance with 10 CFR 50.46. I mean, that is if you believe the experimental data that I cited in the petition.

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

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

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

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

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

Anyway, I guess I'm kind of going off on a tangent, but I'm very well aware of how long the petition review process can take. And I think that this is a very serious issue. We are talking about if you have a loss of coolant accident at this aging plant -- Ray Shadis has discussed some of the problems at Vermont Yankee.

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

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

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

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

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

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

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

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

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

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

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

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

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

MR. SHADIS: Okay. May I add on?

MR. MARK LEYSE: Most certainly.

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

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

And with respect to the specificity of

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

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

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

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

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

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

Thank you.

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

(No response.)

Seeing none, what about the region?

MR. SETZER: No questions. Thank you.

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

(No response.)

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

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

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

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

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

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

CHAIRMAN QUAY: Thank you.

THE COURT REPORTER: Thank you.

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

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

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

CHAIRMAN QUAY: You're welcome. Thank you.

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

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

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

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.

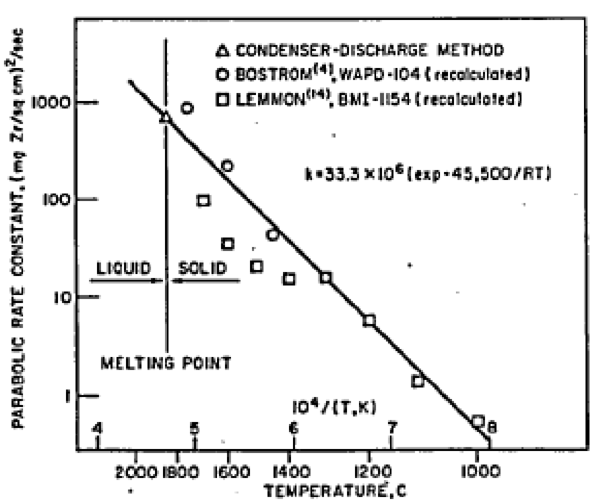
There is no need for considerable technical review and further delays to confirm that 2200 degrees is non-conservative. The evidence is complete.

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.

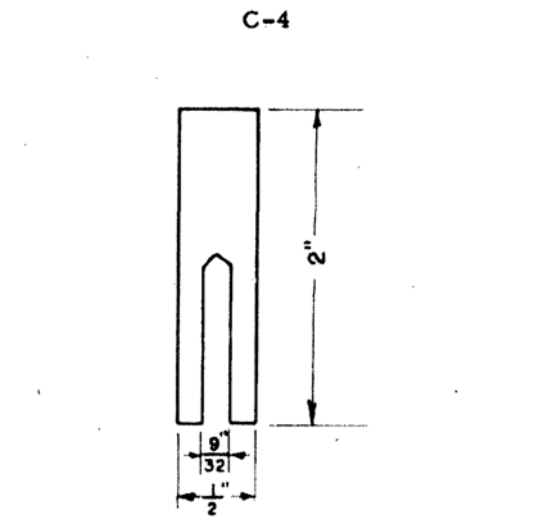
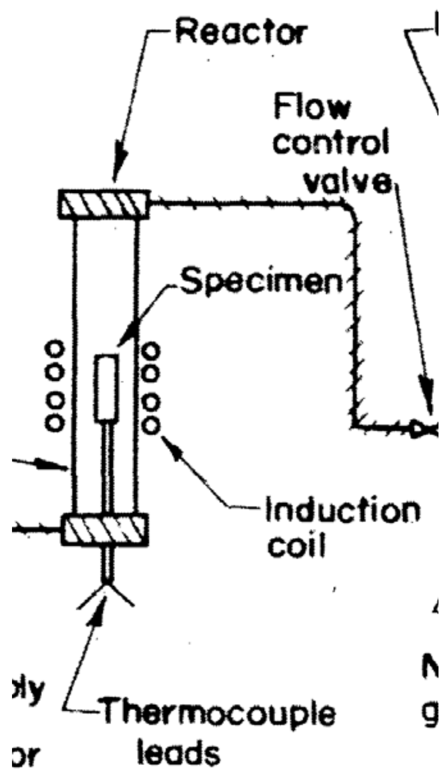


FIGURE C-1. ZIRCALOY 2 SPECIMEN



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

$$Zr + 2H_2O \rightarrow ZrO_2 + 2H_2 + \Delta H_R$$

  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 ¾ 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.