January 30, 2013

For: The Commissioners

Subject: Mark Leyse's Comments for the January 31, 2013 Meeting on Public Participation in NRC Regulatory Decision-Making

THE FISCAL BENEFITS OF PUBLIC PARTICIPATION

I would like to thank the Nuclear Regulatory Commission for inviting me to participate in its January 31, 2013 meeting on public participation in NRC regulatory decision-making. I want to clarify that I am not representing the New England Coalition.

My comments on public participation will be integrated into my comments on enforcement action and rulemaking petitions. Yet I appreciate that the NRC provides teleconferencing. I think it is a great feature.

First, I will discuss enforcement action petitions. Richard Webster of Public Justice P.C. has submitted comments on such petitions and I agree with his points. I think it is constructive that petitioners are allowed to have meetings with Petition Review Boards ("PRB"); however, I think petitioners should be allowed to ask PRBs questions. Having more of a dialogue could help facilitate the resolution of potential safely issues. And I believe in cases in which PRBs claim that given safety issues have been resolved, PRBs should be required to provide documentation demonstrating that the given issues have indeed been resolved.

PRB meetings allow petitioners to clarify the safety issues they are concerned about. Having meetings with petitioners saves time—a PRB can ask questions and learn about issues which were perhaps not clearly stated; or were perhaps confusing. The process is expedited. This is one example of the fiscal benefits of public participation.

To provide an example: last year, Natural Resources Defense Council submitted an enforcement action petition on a safety issue regarding passive autocatalytic recombiners—which are intended to eliminate hydrogen in accidents. This type of recombiner can malfunction and have ignitions when exposed to elevated hydrogen concentrations—such as would occur in a severe accident. An ignition could cause a hydrogen detonation. The PRB's initial decision was to not consider the petition. Yet after a second meeting, in which the petitioner was given the opportunity to answer questions and contend that the safety issue had not been resolved, the PRB reversed its initial decision. Hence, I think meetings between petitioners and PRBs are valuable.

Next, I will discuss petitions for rulemaking ("PRM"). I have reviewed the proposed rule for expanding the authority of the Executive Director for Operations to deny PRMs. I understand that the NRC has limited resources available for processing PRMs and that the NRC is concerned that there have been a number of petitions submitted in recent years.

Among other things, it is proposed that the EDO be allowed to deny a PRM if it raises issues already raised in an enforcement action petition. I do not think that is a good idea. I realize that 23 PRMs were submitted in 2007; as it turns out, that was the same year I submitted PRM-50-84 on how crud deposits on fuel cladding would increase the maximum cladding temperature in a loss-of-coolant accident. That petition was accepted and became part of the staff's revision of Section 50.46(b)—which is now Section 50.46(c).

I would suggest that the staff review how much it cost to revise Section 50.46(c). I would wager that the cost of the revisions would have been higher (if the same end result were achieved) if I had not submitted a PRM on crud deposits. To clarify: I spent hundreds of hours researching my PRM; that is research the NRC did not have to pay for. (I am not complaining—just making a point.) Before expanding the authority to deny PRMs, I would suggest investigating the fiscal benefits of PRMs. PRMs also play a role in improving nuclear safety.

There should be more public participation in the rulemaking petition process. I think that there should be meetings between petitioners and the technical staff who review PRMs—just like there are meetings between petitioners and PRBs for enforcement action petitions. (Diane Curran of Harmon, Curran, Spielberg, and Eisenberg, LLP suggested this idea to me.) There should be publically available transcripts of such meetings; and petitioners should be allowed to ask questions. I think that such meetings would help cut the expenses of the PRM review process. Issues which were perhaps not clearly stated or were perhaps confusing could be clarified.

To provide an example: currently, technical staff are reviewing PRM-50-93, a petition I submitted in 2009, and the staff have overlooked a number of important points. They have released three interim reviews. In one review, they concluded that runaway oxidation (or thermal runaway of fuel cladding temperatures) has not commenced below 2200°F; however, in a different review, they reported data from the LOFT LP-FP-2 experiment demonstrating that thermal runaway had commenced below 2200°F. Incidentally, there is a document for an NRC safety course which states that in a postulated station blackout scenario at Grand Gulf, runaway zirconium oxidation would commence at 1832°F.

In comments on PRM-50-93, I submitted information from an OECD Nuclear Energy Agency report, explicitly stating that hydrogen generation rates recorded in LOFT LP-FP-2 and other experiments were under-predicted by computer safety models using existing zirconium-steam correlations—the correlations are inadequate. This information has been overlooked by the staff. When the staff do MELCOR calculations for Fukushima, they should keep in mind that hydrogen generation rates will be under-predicted. This is problematic for designing hydrogen mitigation systems.

Finally, the staff has done TRACE code simulations of a design basis accident experiment Westinghouse conducted—FLECHT run 9573—and the section of the test bundle that incurred runaway oxidation was not simulated. Westinghouse reported that the section of the test bundle that incurred runaway oxidation, reached temperatures exceeding 2500°F, which is more than 80°F higher than the highest temperature predicted by NRC's TRACE simulation using the Baker-Just correlation. The Baker-Just correlation is supposed to be conservative.

One cannot do legitimate computer simulations of an experiment that incurred runaway oxidation by not modeling the section of the test bundle that incurred runaway oxidation. Hence, the staff's TRACE code simulations were a waste of money; and I understand that the NRC has limited resources available for processing PRMs. I think it would be constructive if, as a petitioner, I could meet with the staff who are reviewing PRM-50-93. Having such meetings would save time and reduce the cost of reviewing PRMs.

Respectfully submitted,

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Enclosure:
Appendix 1 A Few Issues Raised in PRM-50-93 the Technical Staff Has Overlooked, Covered Briefly

Appendix 1. A Few Issues Raised in PRM-50-93 the Technical Staff Has Overlooked, Covered Briefly

I. Runaway Oxidation (Thermal Runaway of Fuel Cladding Temperatures) Has Commenced below 2200°F

Regarding the 2200°F 10 C.F.R. § 50.46(b)(1) fuel peak cladding temperature ("PCT") limit, in NRC's October 2012 Draft Interim Review of PRM-50-93/95, NRC concludes:

> [A]utocatalytic reactions have not occurred at temperatures less than 2200 degrees F. Accordingly, the 2200 degree F regulatory limit is sufficient provided the correlations used to determine the metal-water reaction rate below 2200 degrees F are suitably conservative such that excessive reaction rates do not occur below that value.[1]

In PRM-50-93/95 and in comments on PRM-50-93/95, Petitioner submitted information stating that runaway (autocatalytic) zirconium-steam reactions ("runaway oxidation") *have* commenced when fuel-cladding temperatures were lower than the 2200°F PCT limit. For example, PRM-50-93 (pages 46-47) quotes an OECD Nuclear Energy Agency report, which states that runaway oxidation occurs at temperatures of 1050-1100°C (1922-2012°F) or greater.[2] In NRC's October 2012 Draft Interim Review of PRM-50-93/95, NRC neither discusses nor mentions such information.

Interestingly, an NRC document, "Perspectives on Reactor Safety," states that in a postulated station blackout scenario at Grand Gulf, runaway zirconium oxidation would

[1] NRC, "Draft Interim Review of PRM-50-93/95 Issues Related to Conservatism of 2200 degrees F, Metal-Water Reaction Rate Correlations, and 'The Impression Left from [FLECHT] Run 9573' ," October 16, 2012, available at: NRC's ADAMS Documents, Accession Number: ML12265A277, p. 2.

[2] T. J. Haste, K. Trambauer, OECD Nuclear Energy Agency, Committee on the Safety of Nuclear Installations, "Degraded Core Quench: Summary of Progress 1996-1999," Executive Summary, February 2000, p. 9. (Regarding the statement that runaway (autocatalytic) oxidation occurs at temperatures of 1050-1100°C (1922-2012°F) or greater, "Degraded Core Quench: Summary of Progress 1996-1999" explicitly states that "[a] notable feature of the [QUENCH] experiments was the occurrence of temperature excursions starting in the unheated region at the top of the shroud, from temperatures of 750-800°C, which is more than 300 K lower than excursion temperatures associated with runaway oxidation by steam.")

commence at 1832°F.[3] (This information was neither provided in PRM-50-93/95 nor in comments on PRM-50-93/95.)

Furthermore, in NRC's own September 2011 Draft Interim Review of PRM-50-93/95, NRC presented data demonstrating that runaway oxidation commenced in the LOFT LP-FP-2 experiment when fuel-cladding temperatures were lower than 2200°F. (In PRM-50-93 (pages 27, 33, 41, 42), Petitioner quoted a Pacific Northwest Laboratory paper, which states that "a rapid [cladding] temperature escalation, [greater than] 10 K/sec [18°F/sec], signal[s] the onset of an autocatalytic oxidation reaction."[4] This is for cases in which there would be relatively low initial heatup rates—for example, 1.0 K/sec (1.8°F/sec)—followed by substantially higher heatup rates, caused by the contribution of heat generated by the exothermic oxidation reaction.) In NRC's September 2011 Draft Interim Review of PRM-50-93/95, NRC presented data stating that in LOFT LP-FP-2, when local temperatures reached 1477 K (2199.2°F), the heatup rates at two fuel-cladding locations (TE-5C07-042 and TE-5D13-042) were 10.3 K/sec (18.5°F/sec) and 11.9 K/sec (21.4°F/sec), respectively.[5]

Hence, NRC's October 2012 Draft Interim Review of PRM-50-93/95 overlooks data that NRC provided in September 2011 demonstrating that runaway oxidation commenced in LOFT LP-FP-2 when fuel-cladding temperatures were lower than the 2200°F PCT limit. Clearly, NRC needs to correct its erroneous conclusion that runaway oxidation has not commenced when fuel-cladding temperatures were lower than the 2200°F PCT limit.

It is noteworthy that a report regarding best-estimate predictions for LOFT LP-FP-2 states that runaway oxidation would commence if fuel-cladding

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[3] NRC, "Perspectives on Reactor Safety," NUREG/CR-6042, Rev. 2, March 2002, available at: NRC's ADAMS Documents, Accession Number: ML021080117, pp. 3.7-4, 3.7-5, 3.7-29.

[4] F. E. Panisko, N. J. Lombardo, Pacific Northwest Laboratory, "Results from In-Reactor Severe Fuel Damage Tests that used Full-Length Fuel Rods and the Relevancy to LWR Severe Accident Melt Progression Safety Issues," in "Proceedings of the U.S. Nuclear Regulatory Commission: Twentieth Water Reactor Safety Information Meeting," NUREG/CP-0126, Vol. 2, 1992, available at: NRC's ADAMS Documents, Accession Number: ML042230126, p. 282.

[5] NRC, "Draft Interim Review of PRM-50-93/95 Issues Related to the LOFT LP-FP-2 Test," September 2011, available at: NRC's ADAMS Documents, Accession Number: ML112650009, p. 4.

temperatures were to start increasing at a rate of 3.0 K/sec (5.4°F/sec);[6] this is for cases in which there would be relatively low initial heatup rates. (This information was neither provided in PRM-50-93/95 nor in comments on PRM-50-93/95.)

II. Computer Safety Models Are Unable to Determine the Increased Hydrogen Production Which Occurred in the CORA and LOFT LP-FP-2 Experiments

Regarding the CORA severe accident experiments and the Cathcart-Pawel and Baker-Just correlations, in NRC's August 2011 Draft Interim Review of PRM-50-93/95, NRC concludes:

> The results of [the] CORA [experiments] do not suggest that the Cathcart-Pawel or Baker-Just correlations are non-conservative. The assertions made by the petition with regards to Cathcart-Pawel and Baker-Just are not substantiated by the CORA data."[7]

And regarding the LOFT LP-FP-2 severe accident experiment and the Cathcart-Pawel and Baker-Just correlations, in NRC's September 2011 Draft Interim Review of PRM-50-93/95, NRC concludes:

> The results of LOFT Test LP-FP-2 do not…suggest that the Cathcart-Pawel or Baker-Just correlations are non-conservative. The assertions made in PRM-50-93/95 with regards to Cathcart-Pawel and Baker-Just are not substantiated by the results of this LOFT test."[8]

In Petitioner's comments on PRM-50-93/95 (page 5), dated April 7, 2011,[9] Petitioner quoted an OECD Nuclear Energy Agency report, published in 2001, which explicitly states that "[t]he available Zircaloy-steam oxidation correlations were not suitable to determine the increased hydrogen production in the [CORA and LOFT LP-FP-2] experiments."[10] Yet NRC's draft interim reviews of PRM-50-93/95 on

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[6] S. Guntay, M. Carboneau, Y. Anoda, "Best Estimate Prediction for OECD LOFT Project Fission Product Experiment LP-FP-2," OECD LOFT-T-3803, June 1985, available at: NRC's ADAMS Documents, Accession Number: ML071940361, p. 38.

[7] NRC, "Draft Interim Review of PRM-50-93/95 Issues Related to the CORA Tests," August 2011, available at: NRC's ADAMS Documents, Accession Number: ML112290888, p. 3.

[8] NRC, "Draft Interim Review of PRM-50-93/95 Issues Related to the LOFT LP-FP-2 Test," p. 5.

[9] Mark Leyse, Comments on PRM-50-93/95, April 7, 2011, available at: NRC's ADAMS Documents, Accession Number: ML111020046.

[10] Report by Nuclear Energy Agency ("NEA") Groups of Experts, OECD Nuclear Energy Agency, "In-Vessel and Ex-Vessel Hydrogen Sources," NEA/CSNIIR(2001)15, October 1, 2001, Part I, B. Clement (IPSN), K. Trambauer (GRS), W. Scholtyssek (FZK), Working Group on the

the CORA and LOFT LP-FP-2 experiments neither discuss nor mention the Nuclear Energy Agency statement—instead NRC claims that the CORA data and LOFT LP-FP-2 data confirm that the Cathcart-Pawel and Baker-Just correlations are conservative for use in computer safety models.

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III. NRC's TRACE Simulations of FLECHT Run 9573 Are Invalid because They Did Not Simulate the Section of the Test Bundle That Incurred Runaway Oxidation

Section of the Bundle from FLECHT Run 9573

In NRC's October 2012 Draft Interim Review of PRM-50-93/95, NRC discusses TRACE simulations of FLECHT run 9573 that it performed.[11] (FLECHT run 9573 was a design basis accident experiment.) NRC provides results of its TRACE simulations for the 2, 4, 6, 8, and 10-foot elevations of the FLECHT run 9573 bundle, which were the elevations where thermocouples were located on the bundle.[12]

Analysis and Management of Accidents, "GAMA Perspective Statement on In-Vessel Hydrogen Sources," p. 9.

[11] NRC, "Draft Interim Review of PRM-50-93/95 Issues Related to Conservatism of 2200 degrees F, Metal-Water Reaction Rate Correlations, and 'The Impression Left from [FLECHT] Run 9573' ," pp. 7-8.

[12] F. F. Cadek, D. P. Dominicis, R. H. Leyse, Westinghouse Electric Corporation, "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," WCAP-7665, April 1971, available at: NRC's ADAMS Documents, Accession Number: ML070780083, p. 2-10.

Unfortunately, in FLECHT run 9573 there were no thermocouples located at the section of the bundle which incurred runaway oxidation—"within approximately ±8 inches of a Zircaloy grid at the 7 ft elevation."[13] (There was a steam probe thermocouple located at the 7-foot elevation.[14]) Hence, NRC's TRACE simulations did not include the section of the FLECHT run 9573 bundle that incurred runaway oxidation.

As stated in PRM-50-93 (pages 59, 60), Westinghouse reported, regarding the FLECHT run 9573 bundle, that a "[p]ost-test bundle inspection indicated a locally severe damage zone within approximately ±8 inches of a Zircaloy grid at the 7 ft elevation."[15] And, as stated in PRM-50-93 (page 60), Westinghouse reported that "[t]he remainder of the [FLECHT run 9573] bundle was in excellent condition." [16]

(Appendix A of PRM-50-93 has photographs of the "locally severe damage zone," which incurred runaway oxidation, of the bundle from FLECHT run 9573.)

It is reasonable to assume that—as in CORA-2, in which local steam starvation conditions are postulated to have occurred[17]—in FLECHT run 9573, violent oxidation essentially consumed much of the available steam, so that time-limited and local steam starvation conditions, which cannot be detected in a post-test investigation, would have occurred.

Therefore, NRC's TRACE simulations for FLECHT run 9573, using the Baker-Just and Cathcart-Pawel correlations, encompassed locations—the 2, 4, 6, 8, and 10-foot elevations of the bundle—that most likely were steam starved or partly steam starved (hydrogen produced by the zirconium-steam reaction would have also diluted the available steam). Clearly, NRC's TRACE simulations are not legitimate verifications of the adequacy of the Baker-Just and Cathcart-Pawel correlations for use in computer safety models.

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[13] *Id.*, p. 3-97.
[14] *Id.*, p. 2-13.
[15] *Id.*, p. 3-97.
[16] *Id.*
[17] S. Hagen, P. Hofmann, G. Schanz, L. Sepold, "Interactions in Zircaloy/UO_2 Fuel Rod Bundles with Inconel Spacers at Temperatures above 1200°C (Posttest Results of Severe Fuel Damage Experiments CORA-2 and CORA-3)," Forschungszentrum Karlsruhe, KfK 4378, September 1990, p. 41.

A. NRC's TRACE Simulations of FLECHT Run 9573 Did Not Include Data Taken from the Seven-Foot Elevation of the Bundle

The highest predicted temperature in NRC's TRACE simulations of FLECHT run 9573 was 1598.4 K (2417.7°F) at the 6-foot elevation, *at 18 seconds* after flooding commenced: predicted by the TRACE simulation using the Baker-Just correlation. As stated in PRM-50-93 (pages 10-11, 59, 63), Westinghouse reported that steam temperatures (measured by the seven-foot steam probe) exceeded 2500°F *at 16 seconds* after flooding commenced in FLECHT run 9573.[18] And, as stated in PRM-50-93 (pages 59-60, 60-61), Westinghouse reported that "[t]he heater rod failures were apparently caused by localized temperatures in excess of 2500°F."[19] Therefore, at locations at which heater rods stated to fail at approximately 18 seconds after flooding commenced, the localized temperatures were in excess of 2500°F—more than 82°F higher than the highest temperature predicted by NRC's TRACE simulation using the Baker-Just correlation.

As stated in PRM-50-93 (pages 66-67), Westinghouse reported, regarding the FLECHT run 9573 bundle that "[t]he steam probe thermocouple located one foot above midplane [at the 7-foot elevation] in close proximity to a Zircaloy grid indicated an extremely rapid rate of temperature rise (over 300°F/sec) beginning approximately 12 seconds after flooding and reaching 2450°F by 16 seconds after flooding."[20] (Appendix I of PRM-50-93 is a Westinghouse memorandum, dated December 14, 1970, reporting that the steam heatup rate exceeded 300°F/sec, at the 7-foot elevation.)

Hence, there is yet another reason why NRC's TRACE simulations FLECHT run 9573 were not legitimate verifications of the adequacy of the Baker-Just and Cathcart-Pawel correlations for use in computer safety models. NRC's TRACE simulations did not include data taken from the 7-foot elevation of the FLECHT run 9573 bundle, where a steam probe thermocouple measured steam temperature heatup rates that exceeded 300°F/sec.

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[18] F. F. Cadek, D. P. Dominicis, R. H. Leyse, "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," p. 3-97.

[19] *Id*.

[20] Robert H. Leyse, Westinghouse, Nuclear Energy Systems, Test Engineering, Memorandum RD-TE-70-616, "FLECHT Monthly Report," December 14, 1970.

It is unfortunate that NRC has overlooked the *new information* on FLECHT run 9573—not discussed in PRM-50-76—that Petitioner provided in PRM-50-93 and in comments on PRM-50-93/95.