PRM-50-84
(72FR28902)

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OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

August 5, 2007

Annette L. Vietti-Cook
Secretary
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Rulemaking and Adjudications Staff

Public Comment on PRM-50-84

Dear Ms. Vietti-Cook:

In PRM-50-84, among other requests, Petitioner requested that the Nuclear Regulatory Commission ("NRC") amend Appendix K to Part 50—ECCS Evaluation Models I(A)(1), *The Initial Stored Energy in the Fuel*, to require that the steady-state temperature distribution and stored energy in the fuel at the onset of a postulated LOCA be calculated by factoring in the role that the thermal resistance of crud and/or oxide layers on cladding plays in increasing the stored energy in the fuel. Petitioner also requested that Appendix K to Part 50 provide instructions for how to carry out ECCS evaluation calculations that factor in the role that the thermal resistance of crud and/or oxide layers on cladding plays in determining the quantity of stored energy in the fuel at the onset of a postulated LOCA. Additionally, Petitioner requested that these same requirements apply to any NRC approved best-estimate ECCS evaluation models used in lieu of Appendix K to Part 50 calculations.

By realistically modeling crud and/or oxide layers on cladding in ECCS evaluation calculations, all holders of operating licenses for nuclear power plants, would help ensure that such calculations comply with 10 C.F.R. § 50.46(a)(1)(i), which requires that "ECCS cooling performance must be calculated...to provide assurance that the most severe postulated loss-of-coolant accidents are calculated." This, in turn, would help ensure that plants operate in compliance with the parameters set forth in 10 C.F.R. § 50.46(b).

In this public comment on PRM-50-84, Petitioner provides additional information that illustrates why it is essential that the steady-state temperature distribution and stored energy in the fuel at the onset of a postulated LOCA be calculated by factoring in the role

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that the thermal resistance of crud and/or oxide layers on cladding plays in increasing the stored energy in the fuel. Not covered in PRM-50-84, is that, in addition to increasing the stored energy in the fuel, the thermal resistance of crud and/or oxide layers on cladding also increases fuel rod internal pressure.

Regarding this phenomenon, NRC document, "Safety Evaluation by the Office of Nuclear Regulation, Topical Report WCAP-15604-NP. REV. 1, 'Limited Scope High Burnup Lead Test Assemblies' Westinghouse Owners Group, Project No. 694," states:

> Clad[ding] oxidation can lead to significantly increased fuel rod internal pressures. Above certain oxidation levels, the impacts on rod internal pressure and the significant impacts on the cladding pressure limit characteristics could result in the rod internal pressure criterion being exceeded. Therefore, if oxidation is kept to a minimum, the fuel rod internal pressure criterion is less limiting than simply the oxidation criterion by itself. ... In addition to oxidation causing increases in rod internal pressures, crud deposition has a similar effect since crud is a poor conductor of heat. Keeping crud deposition to a minimum also reduces the impact on rod internal pressures.[1]

The "fuel rod internal pressure criterion" referred to in the above citation is "a criterion requiring that the internal pressure of the fuel rod not exceed reactor coolant system pressure."[2] Concerning cladding sheathing high burnup fuel, "NRC Information Notice 98-29: Predicted Increase in Fuel Rod Cladding Oxidation" explains that fuel-cladding gap reopening may occur "when internal pressure in the [fuel] rod exceeds reactor coolant system pressure."[3] Concerning the possibility of gap reopening due to the low thermal conductivity of oxide layers on high burnup cladding, "NRC Information Notice 98-29" states:

> Using the corrected corrosion model, Westinghouse interpreted the PAD [computer code (Westinghouse Improved Performance Analysis and Design Model)] results to indicate that the degraded thermal conductivity of the cladding due to the higher oxidation levels produced an increase in fuel

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[1] NRC, "Safety Evaluation by the Office of Nuclear Regulation, Topical Report WCAP-15604-NP. REV. 1, 'Limited Scope High Burnup Lead Test Assemblies' Westinghouse Owners Group, Project No. 694," 2003, located at: www.nrc.gov, Electronic Reading Room, ADAMS Documents, Accession Number: ML070740225 (See Section A), p. 4.

[2] NRC, "NRC Information Notice 98-29: Predicted Increase in Fuel Rod Cladding Oxidation," August 3, 1998, located at: http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1998/in98029.html (accessed on 01/21/07).

[3] Id.

> cladding temperatures and consequent higher clad creep rates. These higher creep rates could, in turn, lead to gap reopening, which would be contrary to a Westinghouse design criterion.[4]

It is significant that the thermal resistance of crud and/or oxide layers on cladding increases the fuel rod internal pressure and affects the fuel-cladding gap width, because internal pressure and the status of the fuel-cladding gap width are phenomena that Appendix K to Part 50 currently requires to be factored into calculations of the stored energy in the fuel. To calculate "the steady-state temperature distribution and stored energy in the fuel...for the burn-up that yields the highest calculated cladding temperature" Appendix K to Part 50 requires that:

> [T]he thermal conductivity of the UO2...be evaluated as a function of burn-up and temperature, taking into consideration differences in initial density, and the thermal conductance of the gap between the UO2 and the cladding...be evaluated as a function of the burnup, taking into consideration fuel densification and expansion, the composition and *pressure of the gases within the fuel rod, the initial cold gap dimension with its tolerances and cladding creep* [emphasis added].

Clearly, not realistically modeling crud and/or oxide layers in ECCS evaluation calculations would already be a violation of Appendix K to Part 50, because Appendix K to Part 50 requires that ECCS evaluation calculations "[take] into consideration...the composition and pressure of the gases within the fuel rod, the initial cold gap dimension with its tolerances and cladding creep," to determine "the thermal conductance of the gap between the UO2 and the cladding." If ECCS evaluation calculations do not factor in the thermal resistance of crud and/or oxide layers on cladding, such calculations will not properly determine "the thermal conductance of the gap between the UO2 and the cladding" or "the steady-state temperature distribution and stored energy in the fuel." And improperly calculating "the steady-state temperature distribution and stored energy in the fuel" would undermine the primary purpose of Appendix K to Part 50, regarding the stored energy in the fuel: to calculate the stored energy in the fuel that "yields the highest calculated cladding temperature."

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[4] Id.

It is also significant that, in some cases, thick crud and oxide layers have quickly accumulated on one-cycle cladding sheathing high-duty fuel. (At Three Mile Island Unit 1 Cycle 10, such cladding was perforated by oxidation only 121 days into the cycle.[5]) It is highly probable—because of substantial increases in fuel rod internal pressure—that quickly accumulated layers of crud and oxide on one-cycle cladding sheathing high-duty fuel would slow down fuel-cladding gap closure from normal closure rates, during operation or prevent fuel-cladding gap closure, altogether. And prevent cladding from "creep[ing] down towards the fuel pellets, due to the system pressure exceeding the [fuel] rod internal pressure...relatively early in the first cycle of operation"[6] (as a recent Entergy document, describes clean-cladding behavior at pressurized water reactors). This effect would prevent the reduction of the average temperature "at the hot spot [of the fuel rod] by several hundred degrees [Fahrenheit] relatively early in the first cycle of operation"[7] (as the same Entergy document, describes fuel (sheathed in clean-cladding) behavior).

It is clear that crud and/or oxide layers on cladding affect the stored energy in the fuel in two ways: 1) their external thermal resistance increases the stored energy in the fuel and 2) their external thermal resistance increases the fuel rod internal pressure and affects the fuel-cladding gap width, which, in turn, affects the thermal conductance of the fuel-cladding gap and the quantity of the stored energy in the fuel. Therefore, it is imperative that the NRC amend Appendix K to Part 50 to require that the steady-state temperature distribution and stored energy in the fuel at the onset of a postulated LOCA be calculated by factoring in the role that the thermal resistance of crud and/or oxide layers on cladding plays in increasing the stored energy in the fuel, and that Appendix K to Part 50 also provide instructions for how to carry out calculations that factor in the role that the thermal resistance of crud and/or oxide layers on cladding plays in determining the quantity of stored energy in the fuel at the onset of a postulated LOCA. Such

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[5] R. Tropasso, J. Willse, B. Cheng, "Crud-Induced Cladding Corrosion Failures in TMI-1 Cycle 10," American Nuclear Society, Proceedings of the *2004 International Meeting on LWR Fuel Performance*, Orlando, Florida, September 19-22, 2004, p. 339.

[6] Entergy, Attachment 1 to NL-04-100, "Reply to NRC Request for Additional Information Regarding Proposed License Amendment Request for Indian Point 2 Stretch Power Uprate," August 12, 2004, located at: www.nrc.gov, Electronic Reading Room, ADAMS Documents, Accession Number: ML042380253, p. 6.

[7] Id.

requirements also must apply to any NRC approved best-estimate ECCS evaluation models used in lieu of Appendix K calculations.

Sincerely,

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To: <SECY@nrc.gov>
Date: Mon, Aug 6, 2007 12:21 PM
Subject: Attn: Rulemaking and Adjudications Staff; Public Comments on PRM-50-84

Dear Ms. Vietti-Cook:

Attached in two PDF files are two separate letters with comments on PRM-50-84.

Thank you,

Mark Edward Leyse

CC: Dave Lochbaum <dlochbaum@ucsusa.org>

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