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NUCLEAR ENERGY INSTITUTE

PRM-50-84
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RULEMAKINGS AND
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Ms. Annette L. Vietti-Cook
Secretary
Rulemaking and Adjudications Staff
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Leyse Petition for Rulemaking: PRM-50-84

Project Number: 689

On May 23, 2007, the Federal Register published for comment a petition for rulemaking by Mr. Mark Edward Leyse who submitted this petition pursuant to Title 10 of the *Code of Federal Regulations* (10CFR) Section 2.802. It requests new regulations to effectively limit the thickness of crud and/or oxide layers on fuel rod cladding surfaces during normal operations, so that compliance with 10CFR50.46 is ensured. The petition also requests that the NRC amend Appendix K to Part 50 Emergency Core Cooling System (ECCS) Evaluation Models to require that the steady-state temperature distribution and stored energy in the fuel at the onset of a postulated Loss of Coolant Accident (LOCA) be calculated by including the thermal resistance effects of crud and/or oxide layers on the cladding surface. The petition further specifies that these requirements should also apply to any NRC approved best-estimate ECCS evaluation model. Finally, the petition requests that the NRC amend 10CFR50.46 to include a regulation stipulating a maximum allowable percentage of hydrogen content in the cladding.

The Nuclear Energy Institute (NEI)[1] offers the following comments on the petition for rulemaking.

1. It should be noted that the petitioner relies heavily on four abnormal operating experiences at River Bend (1998-99 and 2001-03), Three Mile Island Unit 1 (1995), Palo Verde Unit 2

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all utilities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

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(1997), and Seabrook Nuclear Operating Unit (1997). These units all experienced localized sections of thick crud formation during normal operation. The Industry has taken corrective actions to mitigate both general and localized crud formation during operation. These actions include developing revisions to existing water chemistry guidelines.

2. It is well recognized that the effects of corrosion on the cladding and grid spacer surfaces and other fuel system structural components need to be considered to ensure that fuel system dimensions remain within operational tolerances and that functional capabilities are not reduced below those assumed in the safety analyses. Guidelines in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design" do not specify an explicit limit on the maximum allowable corrosion thickness. The guidance contained in SRP Section 4.2 does require that the impact of corrosion on the thermal and mechanical performance be considered in the fuel design analysis, when comparing to the design stress and strain limits. For the fuel rod cladding, the effects include:

   (I) The heat transfer resistance provided by the cladding oxide and crud layers, thereby increasing cladding and fuel pellet temperatures,
   (II) The metal loss as a result of the corrosion reaction, thereby reducing the cladding load carrying ability.

   These effects are already considered in the design analyses to ensure that the cladding does not exceed the mechanical design limits e.g. design stress and design strain.

3. Approved fuel performance models are used to determine fuel rod conditions at the start of a postulated LOCA. The impact of crud and oxidation on fuel temperatures and pressures may be determined explicitly or implicitly in the system of models used. The impact of crud and oxidation is addressed, since the system of approved models is benchmarked to temperature and fission gas release data which inherently include corrosion up to high burnup levels.

4. For those Pressurized Water Reactor (PWR) cases cited in the petition in which unusual crud patterns and deposits where observed, post-cycle fuel inspection has shown that there was no significant increase in over-all cladding corrosion compared to existing approved corrosion models. Thus, the cladding temperature was not significantly affected by the presence of the crud with the exception of a very limited number of localized damage sites. These localized damage sites are limited both axially and azimuthally such that their thermal resistance effect on the overall fuel temperature and stored energy is small. Furthermore, any damage on the limited surface area of the cladding affected by unusual crud patterns is no different than other types of cladding damage such as fretting wear or secondary

hydriding of leaking rods. Thus, assuming that cladding with localized crud damage has failed using existing fuel acceptance criteria (e.g. SRP 4.2), consequences associated with unusual crud patterns and deposits are no different than the other types of fuel rod failure modes already accounted for in the plant Technical Specification limits. The Reactor Coolant System (RCS) iodine levels in plant Technical Specification limits inherently restrict the number of damaged rods in a core. Crud-affected fuel rods are not expected to have any significant effects on initial core conditions that could affect LOCA consequences. Any impact on LOCA analyses would be negligible.

5. For the one Boiling Water Reactor (BWR) case cited, in River Bend Cycle 8 significant increases in cladding corrosion were observed only in conjunction with unusually heavy tenacious crud formation. Such crud formation occurred only at lower elevations and thus would have had an impact on the initial stored energy in the fuel only for these locations. Whereas it is true that flow through the affected bundles would be reduced leading to higher initial voiding in the upper part of these bundles, this effect is of secondary importance for a postulated LOCA and is within the envelope determined for core operations with reduced core flow. The calculated Peak Clad Temperature (PCT) in a BWR LOCA event is relatively insensitive to the initial stored energy because PCT values that can challenge the licensing limit occur later in the event and are dominated by the balance between the decay heat and the amount of steam cooling after the initial stored energy difference has been mitigated. It is true that a very early peak in the calculated PCT is sensitive to stored energy but this value is seldom the most limiting value and when it is, this peak is far from the licensing limit of 2200 °F. The similar crud anomaly that occurred for River Bend Cycle 11 was generally considered to be less severe than the Cycle 8 occurrence in that the heavier crud deposition was even more localized. Both events were operational experiences and would not have been prevented or mitigated by the imposition of specific licensing limits on crud thickness. After the second event, River Bend implemented specific hardware changes to prevent further high-crud events based on the root cause determination for these anomalies. These changes have been effective to date.

6. It is true that cladding hydrogen content can have an adverse effect on ductile/brittle behavior of zirconium alloy material heated into the beta phase and quenched (as would occur during a typical LOCA scenario). The hydrogen impact on post-quench cladding ductility is a complex function of the oxidation temperature and pre-quench cooling path. The potential impact of hydrogen on the fuel acceptance criteria specified in 10CFR50.46(b) has been recognized for several years and experimental programs are currently underway to assess this impact on current cladding alloys as well as on newer alloys developed to minimize hydrogen build-up during irradiation. Based on the data being generated from several experimental programs, NRC-RES is in the process of preparing the technical basis

for performance-based fuel acceptance criteria in 10CFR50.46 that include the effects of hydrogen.

In summary, the Industry opinion is that the requirement to consider the impact of crud and/or corrosion layers resident on the fuel rod cladding surface is adequately specified within the current regulations and Staff guidance documents used to prepare and review fuel design and plant safety analyses. The specific incidents referenced by Mr. Leyse in his petition were isolated operational events and would not have been prevented by imposition of specific limits on crud thickness. The Industry is actively pursuing root cause evaluations and has developed corrective actions, including specific hardware changes, to mitigate further cases of excessive crud formation. Any effects of cladding hydrogen content will be addressed in upcoming revisions to criteria under preparation by the NRC Staff.

The Industry position is that the petition for rulemaking submitted by Mr. Leyse is not needed and should not be considered for action by the Nuclear Regulatory Commission. If any further discussion is desired, please contact me at (202) 739-8137; jhr@nei.org or Gordon Clefton at (202) 739-8086; gac@nei.org .

Sincerely,

James H. Riley

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c: Mr. Michael T. Lesar, Chief, Rulemaking, Directives and Editing Branch, NRC
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From: "RILEY, Jim" <jhr@nei.org>
Date: Fri, Aug 3, 2007 4:01 PM
Subject: Leyse Petition for Rulemaking: PRM-50-84

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