AREVA

December 31, 2008
NRC:08:106

Mr. William H. Ruland
Director Division of Safety Systems
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Comments for Proposed Rulemaking 10 CFR 50.46(b)

Ref. 1: Letter, William H. Ruland (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Letter to LOCA Industry," ML083240265 NRR-106, November 24, 2008.

Dear Mr. Ruland,

In the reference letter, the NRC requested information regarding the impact of two-sided oxygen uptake on plant performance during loss-of-coolant accidents (LOCAs). This information is provided in Table 1 of the attachment for PWRs of three different designs each using one of the four separate PWR LOCA evaluation models supported by AREVA.

The questions at the stake holder meetings arise from an NRC proposal that the metric used to demonstrate compliance with the transient oxidation limit at pin locations away from the ruptured location be comprised of doubling the ECR (equivalent cladding reacted) calculated on the exterior of the cladding. The proposal is to account for alpha layer development on the inside of the cladding. Although interior alpha layer development is possible, the experimental evidence for its development, the rate at which it occurs, the important parameters of variation, and the limits of development is essentially nonexistent. Further, as evidenced in the attachment, the result would be a doubling of the reportable ECR for many industry evaluation models (EMs).

The decision to incorporate interior alpha layer development should be based on demonstrated need. Significant alpha layer development is only postulated for fuel that has experienced clad to fuel bonding which only applies to fuel in its second half of life. Further, any assessment of the impact should consider, to the extent practical, the actual physical phenomena during a LOCA (see attachment) and not be promulgated because current EMs may overpredict the ECR at the rupture location.

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If you have any questions related to this submittal, please contact Mr. Bert M. Dunn, by telephone at 434-832-2427 or by e-mail to bert.dunn@areva.com.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Corporate Regulatory Affairs
AREVA NP Inc.

Enclosure

cc: Project 728

Attachment: Physical Effects of Rupture

This attachment provides the results of cladding oxidation calculations for three of the four AREVA supported PWR EMs along with a brief outline of the actual physical occurrences within the core at the rupture location for most of the US PWR fleet. For most of the US PWR fleet, heat transfer enhancements concurrent with rupture assure that the ruptured location oxidation fraction, for power peaking distributions that produce limiting oxidations, is not greater than that which occurs elsewhere on the fuel pin. The enhancements cited have been demonstrated experimentally and serve as the basis for many current EMs. Whether lower oxidation at the rupture location is true of a specific LOCA EM depends on the extent to which that EM credits the appropriate physical processes. For the AREVA PWR EMs, Table 1 provides representative results.

TABLE 1. Local Oxidation Results for AREVA Supported LOCA Evaluation Models

Plant Type	Westinghouse 4-Loop	Westinghouse 4-loop	B&W 4 Vent Valve
AREVA Supporting EM	Lynchburg RSG App. K BAW-10168	Best Estimate EMF-2103	Lynchburg B&W App. K BAW-10192
Clad O.D., in	0.374	0.374	0.43
Clad Thickness, in	0.024	0.024	0.025
Pin Pitch, in	0.496	0.496	0.568
PCT (unruptured nodes), F	2108	1809	2117
ECR (unruptured nodes), %	5.4	1.86	4.3
PCT (ruptured node), F	1722	< 1809	1990
ECR (rupture node), %	2.9	< 1.86	4.5
Strain at Ruptured Node, %	~ 50	NC	~ 55
Flow Area Reduction in Rupture Region, %	~ 55	NC	~ 55

Reported values are for cases resulting in the maximum local oxidation.
The ECR provided is the maximum for the type of location indicated.

The Lynchburg RSG and B&W EMs have relatively complete, yet conservative, accounting for rupture induced cooling effects and provide a reasonable measure of what can actually be expected.

The AREVA Best Estimate EM does not calculate rupture or make specific predictions for PCT, oxidation, or heat transfer at the ruptured location based on the premise that limiting results will not occur at the ruptured location. This approach has been demonstrated as conservative and approved by the NRC.

The Appendix K based SEMPWR-98 LOCA evaluation model is used to support CE plants and some Westinghouse 3 & 4 loop plants. This EM conservatively models rupture induced cooling and typically has results similar to the Lynchburg model but with the rupture node ECR being somewhat closer to the ECR at the unruptured node.

The following is a phenomenological description of the impact of rupture relative to the local oxidation and the peak cladding temperature (PCT) for PWRs that achieve PCT during reflood. Important differences (see Note 1) occur for plants with relatively early PCTs.

Rupture during reflood:

1. Rupture occurs when the peak temperature on a rod exceeds approximately 1600 F.
   - 1.a The local strain of the fuel rod reaches strains of 50 to 100 % increasing the cladding surface area proportionately.
   - 1.b The local gap heat transfer coefficient (HTC) decreases by as much as 80 %.
   - 1.c The cladding interior is exposed to external steam initiating a new oxidation mechanism.
2. Because heat is now removed from the cladding better and the heat to the cladding is reduced, the local cladding temperature decreases by up to 200 F. (see Note 2 on fuel relocation)
3. Once the local clad temperature and fuel temperate differ sufficiently to transfer decay heat, the cladding temperature begins to rise at rates similar to the nearby unruptured regions of the pin.
4. Within a few seconds rupture occurs in adjacent fuel rods at elevations stochastically distributed within the rupture grid span.
   - 4.a Individually each pin acts much like the initial ruptured pin.
   - 4.b As a pin group, rupture induces three additional heat transfer effects.
     - 4.b.1 Turbulence in the flow increases the HTC.
     - 4.b.2 Liquid droplets interact with the blocking cladding surfaces and break up.
       - 4.b.2.a The average droplet diameter in the droplet field is reduced which increases interphase heat transfer.
       - 4.b.2.b Associated with droplet break breakup, a fine droplet field is created which vaporizes almost immediately, reducing the vapor temperature.
   - 4.c The turbulence and fine droplet field reduce the local (ruptured zone) cladding temperatures.
   - 4.d The fine droplet field and the reduced average droplet diameter act to reduce cladding temperature down stream (above) the rupture zone.
5. Because the heat transfer is strongly increased, cladding temperatures in the ruptured region of the pin remain 100 to 300 F below the peak pin temperatures.
6. The oxidation rate is exponentially related to the cladding temperature. Therefore, the local circumferential averaged oxidation fraction (even with clad thinning and double sided oxidation) will likely be less than that at the PCT location.
7. The region of increased cooling in the ruptured zone will cause the PCT to occur just upstream (below) of the rupture zone.

Note 1: This analysis applies to peaking at the 6 to 12 foot core elevations (generally the most limiting in local oxidation) with the PCT occurring during reflood. Peak powers in the lower region are cooled rapidly such that high temperatures do not last for extended periods and local oxidation is not as significant. The B&W design incorporates reactor vessel internals vent valves which improve reflood rates such that PCTs occur very early. For the B&W designs with eight internals vent valves, rupture occurs during a very low heat transfer regime