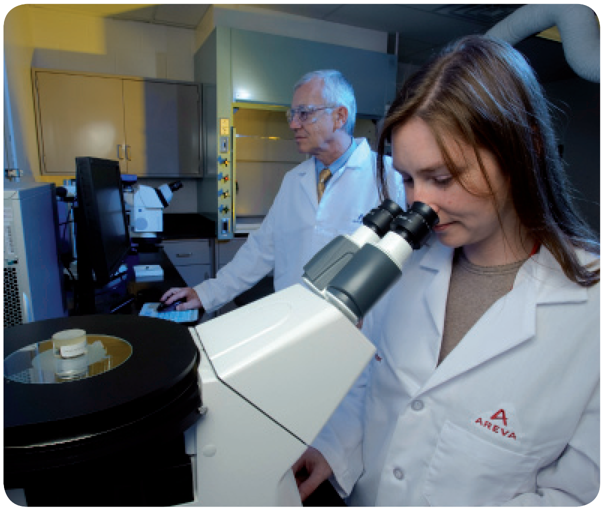
Level III BWR Fuel CRUD Risk Assessment Tools/Methodology

The AREVA Level III fuel crud risk assessment process employs two coupled AREVA tools. The first one is a fuel crud deposition model named FDIC (Fuel Deposit Interfaced with plant Chemistry) to assess/model crud deposition on BWR fuel assemblies over their lifespan [1]. In addition to the FDIC model, another tool PEZOG (Platinum Enhanced Zirconium Oxide Growth) is used for plants using On-Line Noble metal Chemistry (OLNC) technology to address the platinum-enhanced zirconium oxide growth [2]. Detrimental effects of species deposited in crud are evaluated relative to enhanced corrosion and/or detrimental thermal effects (e.g. hot spots). The FDIC-PEZOG-Corrosion tool results in a novel approach to modeling the total impact of crud deposition on fuel reliability.



The AREVA BWR Crud Assessment predicts how crud is deposited on fuel cladding surfaces as a species-differentiated mass per unit area over a function of time. The models incorporates a realistic distribution of steam chimneys and capillaries, based on currently available plant data, which form a sponge-like crud layer in continuous transformation over time. The chemistry engine within the tools is powered by OLI*-Simulation software for electrolyte chemistry, a commercially available computer software package (and associated databases) that simulates aqueous-based chemical systems employing a predictive thermodynamic framework for calculating the physical and chemical properties of multi-phase, aqueous-based systems. An overview of the approach used by the AREVA BWR Crud Model is available in a number of industry presentations [3] [4].

The AREVA tools predict the oxide growth on the fuel clad, the deposited crud thickness, and the platinum, etc. deposited in the crud as the fuel is maintained in the core (over the life to the fuel). The tools have been benchmarked using industry surveillance data; for example, the results from both fuel surveillance/crud sampling and analysis campaigns before and after the first application of OLNC provided physical data that documented the effect of plant operation (plant using OLNC) on both fuel crud deposits and on fuel rod corrosion [5]. Laboratory crud evaluations provided physical benchmarking standard data for direct comparison with the predictions made by the AREVA Risk Assessment Tools, which provided prediction verification. Benchmarking also provided an opportunity to refine and improve the 'first principles' based calculations used for the plant specific application [5].

Features

- Tools used for the analysis have large flexibility, accommodating any type of BWR Fuel with all Chemistry regimens (NWC, HWC, NMCA, OLNC)
- The tools work on a PC Platform
- The whole analysis requires 2 weeks for delivery of preliminary results, after the chemistry and T/H files are formatted for the application

Benefits

- AREVA Level III Fuel Crud Risk Assessment is a benchmarked, ready to use methodology, successfully applied at 5 US BWRs and one European BWR
- The proprietary AREVA methodology has been continuously improved for the last 10 years and is applied by a team of experienced BWR Fuel and Chemistry Applications engineers

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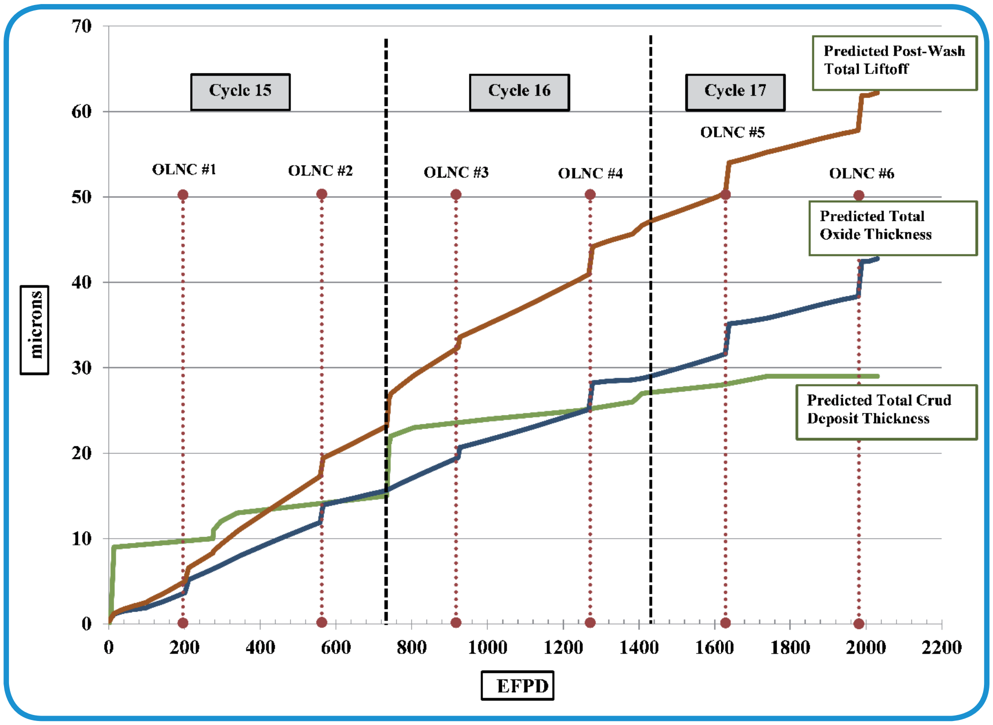

Figure 1: Predicted Post-Washing Total Liftoff Predictions at Crud Induced Localized Corrosion (CILC) Limiting Core Location

In Figure 1, the effect of increased oxide on the total liftoff is seen growing after each OLNC application for a given US BWR Plant. Also the effect of redistribution of crud is seen to be highest at the beginning of the first cycle of fuel operation then decreasing at the beginning of the second and third fuel cycle. The combined effect of crud redistribution and oxide increase after each OLNC application is seen increasing in amplitude towards the end of the life of fuel.

References:

1) U.S. Patent Application No. 14/041,806, Unpublished (filing date Sep. 20, 2013) (Mihai G. M. Pop, applicant).

2) U.S. Patent Application No. 13/751,956, Unpublished (filing date Jan. 28, 2013) (Carola A. Gregorich, applicant).

3) M. Pop, L. Lamanna, M. Bell, J. Riddle, and A. Hoornik, "Use of the AREVA BWR Crud Model to Study High Zinc Operation at a US Plant", 15th International Conference on Environmental Degradation of Materials in Nuclear Power System, Colorado Springs, CO. 7-10 August 2011.

4) T. Keheley, M. Pop, and G. Bhandari, "AREVA NP Approach to Fuel Reliability Using a Combination CFD Fuel Deposition Modeling," Fontevraud 7, Avignon France, 26-30 September 2010.

5) Mike G. Pop, Larry S. Lamanna, Al Hoornik, Gregory C. Storey, James F. Lemons "Benchmarking of AREVA BWR FDIC-PEZOG Model against First BFE3 Cycle 15 Application of On-Line NobleChem™ Results" Fontevraud 8 – Avignon, France – 14-18 September 2014.

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