Chemistry and Crud Risk Assessment Tools

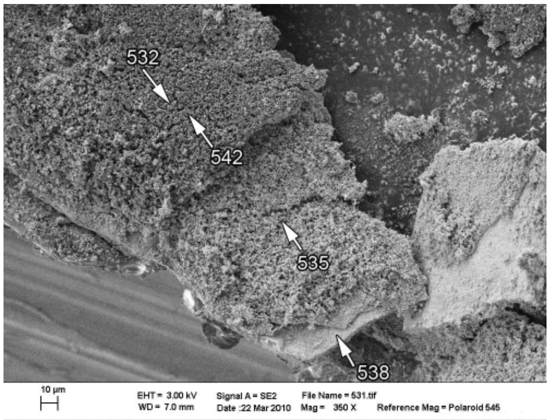
Challenge

A crud-induced power shift (CIPS) occurs when boron precipitates in the fuel crud to a significant concentration for a sufficient period of time to impact localized power levels. The boron accumulation phenomenon is caused by the presence of crud deposits and localized steaming within the crud structure. Crud-induced localized corrosion (CILC) is an accelerated corrosion of the zirconium cladding caused by a number of factors including crud-induced cladding temperature increases, crud thickness, and enhanced corrosion from elevated detrimental levels of species such as lithium.

Solution

Framatome has developed tools and methods for performing EPRI-defined Level III and IV crud risk evaluations. These tools and methods have been successfully applied to support utilities with W, CE, and B&W plants with Framatome fuel in their efforts to manage the risks for crud-related issues. Framatome's CIPS risk assessment includes a core-wide evaluation and a limiting locations evaluation for the specific core design. Our CILC risk assessment is based on, but not limited to, the chemical species at the localized limiting regions and increased temperatures at the cladding surface. The techniques have allowed plants to move from situations of high crud risk, where significant crud deposition was measured, to lower crud risk conditions by using the following elements:

- Localized subchannel and fuel rod resolution in determining the "clean" rod thermal-hydraulic conditions along the full length of each fuel rod
- A thermal-hydraulic subchannel code (COBRA-FLX) benchmarked to evidence of observed in-plant rod surface steaming
- A chemistry tool for predicting crud thickness, under deposit temperature, and crud composition, based on actual plant chemistry data and case studies for the most likely chemistry for the upcoming cycle
- The model is benchmarked to fuel surveillance and crud samples collected (using a sampling method designed to recover intact crud flakes from reference cycles)



Various layers of crud deposition on a zirconium slab. Analysis at Framatome's Chemistry and Materials Center allows identification of species accumulated in, thereby allowing a profound understanding of the deposition processes.

Customer benefits

- Industry-leading capability for predicting Level III and IV crud risks
- Model is benchmarked to fuel surveillance and to crud samples collected
- A subchannel and fuel rod resolution is achieved
- A significant leap forward for predicting the complex nature of crud formation and evolution
- An effective crud risk management capability

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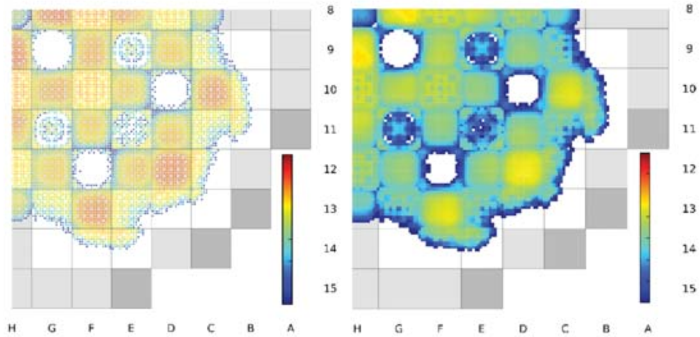
is **our** everyday **commitment**

COBRA-FLX Evaluation

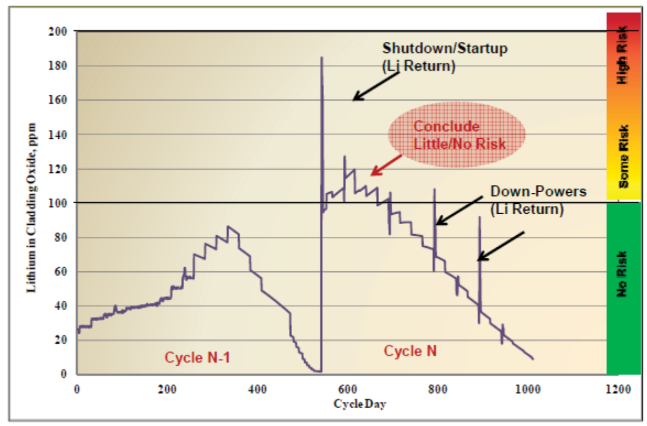
For a Level III evaluation, Framatome's COBRA-FLX thermal-hydraulic subchannel code is used to provide local rod surface and subchannel conditions. Each pin and subchannel is explicitly modeled along with a fine axial mesh to provide an exceptionally high resolution thermal-hydraulic profile of the core. This provides the basis for a highly accurate crud risk assessment.

The outputs from COBRA-FLX and the crud chemistry model are subsequently utilized for the CIPS and CILC risk assessments for the planned core design (Cycle N).



CILC Analysis

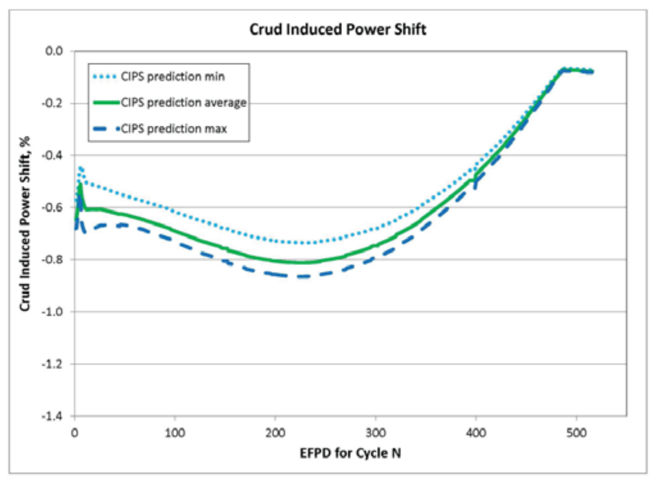
The CILC analysis evaluates the risk of predicted crud deposition for Cycle N compared to Cycles N-1 and N-2. In the example to the right, the lithium (Li) uptake/potential for increased cladding corrosion was assessed as a function of coolant Li concentration, local T-H conditions, and crud thickness. As shown in the figure, the corrosion from Li is predicted to be low.



CIPS Risk Assessment

The CIPS risk is caused by boron deposition within crud. Like the CILC evaluation process, results of COBRA-FLX predictions and chemistry data are used to evaluate the most likely risk of CIPS. The evaluation considers both the limiting locations in the core as well as the overall core-wide risk associated with the cycle's core design.

To the right is an example of CIPS risk assessment results that illustrate the likely CIPS risk along with the upper and lower bounds.



The Framatome Solution

Framatome's advancements in Level III and IV crud risk assessment tools and methods allows it to provide crud risk assessments that more accurately reflect the risk for CIPS and CILC. These advancements have guided utility customers to move away from cycles with high CIPS and CILC risk, and also provided a means to manage crud risks.

Scan to learn more or visit
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