Zinc Addition

Background

The addition of a soluble zinc additive to the reactor coolant in a pressurized water reactor (PWR) leads to the incorporation of zinc into the oxide films that develop on reactor coolant pressure boundary (RCPB) surfaces. This zinc-conditioned oxide is highly protective, reducing all forms of corrosion, and has a number of benefits, including:

- Reduction in plant dose rates and shutdown radiation fields
- Mitigation of primary water stress corrosion cracking (PWSCC)
- Reduction in long-term risk of crud-induced power shift (CIPS), also known as axial offset anomaly (AOA)

To achieve maximum benefits, zinc addition should be implemented as early as possible in the operating life of the plant. Maximizing zinc exposure prior to power uprate and/or steam generator replacement is also strongly recommended.

Benefits

Dose Rate Reduction

Dose rates can be 30-40 percent lower after approximately 200 ppb-months of exposure. Over time, with exposure to zinc, dose rate reductions by a factor of 3 or more can be expected. For example, EPRI and one utility have attributed a 42% dose reduction to zinc addition use over four cycles.

PWSCC Mitigation

PWSCC of Alloy 600 component materials is a major concern for PWRs. There are many locations in the RCPB that contain Alloy 600 base metal or weld metal that could be susceptible to PWSCC over time. Typical locations are shown in the figures on the following page.

Zinc addition is a mitigation technique that benefits all wetted Alloy 600 surfaces within the RCPB. Both laboratory testing and field applications have demonstrated that zinc addition slows the initiation and propagation of PWSCC. Testing performed by Westinghouse for the PWROG has shown that zinc is effective in delaying PWSCC initiation, with a factor of improvement of up to 4.5. The industry is also currently working towards obtaining inspection relief for various components for units adding zinc.

Fuel Performance

Because zinc addition reduces ongoing corrosion of austenitic stainless steel and nickel-based alloys, the long-term risk for CIPS is expected to be lower with sufficient exposure to zinc. There may be an initial increase in the levels of corrosion products in the coolant at a mature plant that initiates zinc injection. This could increase the potential for crud deposition on the fuel, which could increase the risk for CIPS or crud-induced localized corrosion (CILC). The Westinghouse approach minimizes risk to the fuel by employing a plant-specific fuel risk evaluation in order to determine the optimum zinc injection strategy that will also reduce dose rate and mitigate PWSCC.

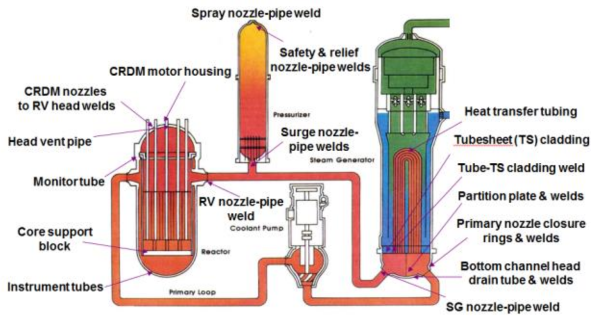
Description

Westinghouse provides several services in support of zinc addition, including:

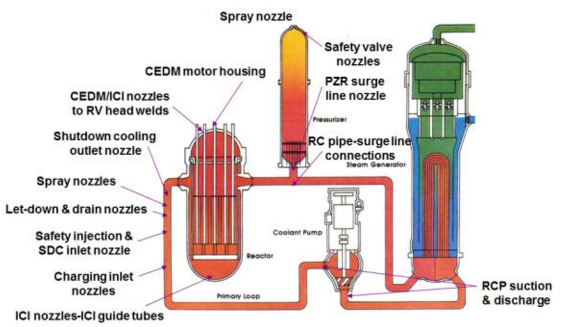
- Fuel risk evaluations
- Plant-specific engineering and safety evaluations related to chemistry, materials, and accident analyses
- 10CFR50.59 documentation
- Implementation support
- Feasibility and cost-benefit studies
- Zinc injection equipment

Experience

The first implementation of zinc addition in a PWR took place in 1994. There are now more than 90 PWRs worldwide injecting zinc. More than 40 percent of the PWRs in the United States that use Westinghouse fuel currently add zinc, including both Westinghouse and Combustion Engineering (CE) design units. Westinghouse has also worked with customers in a number of countries outside the United States to implement zinc addition. This includes applications of zinc starting during hot functional testing of the Westinghouse AP1000™ design.



Alloy 600 Locations in Westinghouse Plants



Alloy 600 Locations in CE Plants

Westinghouse Zinc Injection Skid

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