BNL ALARA CENTER

Processes and Practices Related to Occupational Dose

ID: 37

ROLE OF PH CONTROL IN CONTROLLING PWR RADIATION-FIELD BUILDUP

Keywords: PH; PH CONTROL; CRUD; OPERATIONAL COOLANT CHEMISTRY; COOLANT CHEMISTRY; WATER CHEMISTRY; RADIATION FIELD CONTROL; LITHIUM

Description:

Operational coolant chemistry and in particular the pH value of the coolant is the key operational factor affecting radiation-field buildup. Recent data has shown that there is evidence that increasing the primary coolant pH to about 7.5 will result in a significant decrease in crud transport and plant exposure rates.

Operational chemistry control evolved from use of constant lithium during a cycle (increasing pH) to coordinated lithium-boron (constant pH). The coordinated chemistry was shown to be moderately beneficial in tests at Beaver Valley 1 and Trojan. Evaluation of plant data later indicated that plants operating with high lithium concentrations tended to have better exposure rates than lower lithium plants, suggesting that operation at a higher coolant pH would result in lower exposure rates.

The solubility of crud was computed as a function of temperature for various boric acid concentrations. It was found that lithium concentrations three times (pH of 7.5) those currently recommended (pH of 6.9) are needed to change the coolant characteristics from precipitating to dissolving conditions.

The success of elevated pH chemistry has been demonstrated in Sweden at the Ringhals PWRs. It was also shown there that although the reduction in exposure rates is already significant in plants that have previously operated at normal pH values (Ringhals 2), the improvement in radiation fields is much more striking for those plants which start their operation with elevated pH chemistry (Ringhals 4).

Based on research programs, plant tests and evaluations of plant data it is presently considered that elevating plant pH levels to about 7.5 will result in a significant decrease in crud transport and plant exposure rates. However there are two major concerns: (a) integrity of the fuel, since tests have shown that high lithium hydroxide concentrations in the oxide film increased oxidation rates (b) and primary water stress corrosion cracking of SG tubing in plants with mill-annealed Alloy-600 tubing which has not been stress relieved or peened prior to start-up.

Tests are underway at Millstone-3 and Calvert Cliffs. Both plants have thermally treated Alloy-600 SG tubes which are less likely to crack under typical stress conditions. Based on these and other tests, no adverse effect on SGs is anticipated for plants with thermally treated tubes or mill-annealed tubes that were stress relieved or peened before service. Fuel examination at the two U.S. plants showed oxide thicknesses in the range that would be expected for ordinary chemistry, however at the Ringhals plants the thicknesses increased from 30um at 30 MWd/t to 80um at a burnup of 45 MWd/t (typically acceptible limit is 100um). Also there was some evidence of spalling (undesirable because of radiation