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Processes and Practices Related to Occupational Dose

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OXYGEN CONTROL IN FEEDWATER AND REACTOR WATER

Keywords: OXYGEN CONTROL; FEEDWATER; REACTOR WATER; INTERGRANULAR STRESS CORROSION CRACKING; PWR MAKE-UP WATER SYSTEMS; OPERATIONAL AND CHEMISTRY CONTROLS; BWR

Description:

During the period of high Ni concentration in the feedwater in the intial period of BWR start-up, Fe concentration in the feedwater is increased by lowering the concentration of dissolved oxygen in the feedwater to at least 10 ppb or less, or by adding iron ions or iron oxides to the feedwater during this period, thereby enabling the adhesion of Fe crud on the surface of fuel rods and the effective adsorption and retention of Ni ions brought in over the Fe crud. Subsequently, after the decrease of the Ni concentration in the feedwater, the concentration of the dissolved oxygen in the feedwater is increased over 20 ppb to decrease the Fe concentration in the feedwater, thereby decreasing the amount of the Fe crud on the surface of the fuel rods. This prevents the crud from reaching the limiting value at which crud release occurs; and thereby reduces the buildup of radioactivity on primary piping and components.

References and Selected Abstracts:

1. Kobayashi, M., Osumi, K., Shindo, T., Ito, M., and Uchida, "Nuclear Power Plant," Patent No. JP61-175, 595/A/, pp. 8, August 1986 (in Japanese).

2. Bierman, M.R., Cline, J.E., and Re, G.C., "Analytical Techniques for the Assessment of Environmental Exposure Resulting from Hydrogen Injection Chemistry," Spectrum '86 Proceedings: Volume 2, American Nuclear Society (USA). Fuel Cycle and Waste Management Div., American Nuclear Society (USA). Niagara-Finger Lakes Section. CONF-860905, CONF-860PO5-Vol. 2, pp. 2005-2016, July 1987.

ABSTRACT: It has been observed in boiling water reactors (BWR) that inergranular stress corrosion cracking (IGSCC) of primary steam system pipes and components can occur under certain environmental parameters. One parameter, the oxidizing envrionment that exists, can be reduced by lowering oxygen concentrations via hydrogen injection. This decreases the potential of IGSCC and the production of corrosion products that activate and result in higher levels of radwaste. During normal BWR operations 16N formed from 16O combines in water-soluble nitrates and nitrities. However, the reduction of oxidizing potential created by hydrogen injection increases the amount 16N combined into ammonia (NH3). The increase is transported through the steam system, resulting in increased radiation levels in and around the plant site. Field measurements taken during a hydrogen water chemistry (HWC) mini-test at James A Fitzpatrick Nuclear Power Station permitted the assessment of environmental exposure rate resulting from the increased hydrogen concentration in the feedwater. Adequate data existed from the development of a methodology for estimating exposure rates at and around the plate site based on the hydrogen concentration and main steam line.

3. Naughton, M.D. and Wood, C., J., "Effect of Feedwater Oxygen Control at the Vermont Yankee BWR," EPRI-NP-416P, July 1985.

ABSTRACT: To assess the effectiveness of feedwater oxygen control in reducing the buildup of radiation fields in an operating BWR. This research clearly shows that, under normal operating conditions, feedwater oxygen control plays only a minor role in preventing radiation buildup. In plants whose oxygen levels are within the range of 20-50 ppb, oxygen injection has little effect on corrosion-product input to the reactor system. However, the technique is recommended for plants with oxygen levels below that range. During the injection program, researchers found that oxygen levels of approximately 100 ppb appear to speed the stabilization of nickel oxide films in the feedwater system, thus lowering the input of this element to the reactor. Oxygen injection might therefore benefit plants experiencing high levels of nickel corrosion products in their feedwater. However, the usefulness of the method should be evaluated for each case.

4. Siegwarth, D.P., Bickerstaff, J.A., and Chakravorti, R., "PWR Water Treatment Improvements: Cost-Benefit Analysis," EPRI-NP-5764, Final Report, May 1988, pp. 66.

ABSTRACT: Pressurized water reactor steam generators and turbines have experienced a variety of corrosion problems as a result of ionic, corrosion product and oxidizing species transport in the steam generators. This project considered the design, cost and benefit of equipment modifications and additions which would decrease secondary cycle impurity transport. Improving condenser intergrity, adding full-flow condensate polishers, providing low dissolved oxygen in makeup water and installation of all-ferrous heat exhangers are four changes that can significantly improve secondary water quality. Conceptual designs and costs of these four concepts at a 1160 MWe pressurized water reactor are summarized. The expected chemistry and operational benefits are discussed, and a cost-benefit analysis is given.

5. Wood, C.J. "PWR Primary Water Chemistry Guidelines," EPRI-NP-5960-SR, Special Report, August 1988, pps. 2-2, 2-4.

ABSTRACT: Minimization of coolant oxygen concentrations will lead to minimization of both localized and general corrosion in the RCS. Dissolved oxygen concentrations can be controlled during plant heat-up by the use of venting or vacuum filling followed by the use of hydrazine for residual oxygen scavenging.

During power operation (reactor critical) the reactor coolant oxygen concentration is controlled by the addition of hydrogen and by the minimization of oxygen in the makeup water. For typical PWR flux spectra at 1100-ppm B, Burns showed that hydrogen concentrations of 14-15 cc (STP) H2/kg H20 suppress radiolytically produced oxygen. An adaptation of the Jenks model for computing oxygen formation by radiolysis under PWR conditions suggests that the suppression of the aggressive hydroperoxy (HO2) radical is achieved if 15-20 cc (STP) H2/kg H20 are present in the coolant during power operation. Since oxygen or oxidizing species can also be added to the coolant from other sources, an excess inventory of hydrogen is maintained and oxygen is normally below the analytical detection limit (<5 ppb) while the reactor is at power.

6. Sadler, M.A. , Darvil, M.R., "Oxygen Control in PWR Makeup Water," EPRI-NP-5623, Final Report, January 1988.