N197. Looking for Links between BWR Hydrogen Water Chemistry and Increased Shutdown Dose Rates

Many BWRs have addressed concerns about intergranular stress corrosion cracking (IGSCC) of plant piping and components by switching from an oxygenated environment to a reducing environment using hydrogen injection into the reactor feedwater. One effect of the transition has been increased drywell dose rates at shutdown. The magnitude of this effect has varied considerably from reactor to reactor. Some BWRs experienced little impact; others have measured contact dose rates on recirculation system piping as high as 1,000 to 2,000 mR/h.

In early 1991, EPRI initiated a program to investigate the causes of the dose rate increases and develop mitigation techniques to minimize their impact. When the chemical environment is changed by injecting hydrogen, the stable form of the oxides present in the plant changes from the haematite type of structure to the spinel structure. As this transition occurs, some fraction of the oxides is released to the reactor water in various forms. Although in some plants soluble phase mechanisms do contribute appreciably, it is believed that transport and deposition of the insoluble phase isotopes is most responsible for the increased dose rates.

At one plant with a history of high crud input, the switch to hydrogen water chemistry (HWC) caused the contact dose rates at the standard measurement locations to increase from around 250 mR/h to 900 mR/h. Switching back to normal oxygenated water chemistry in mid-cycle resulted in dose rates near normal at the refueling outage. Inspection of the annulus area of the reactor during the outage showed that crud accumulations observed there previously had now disappeared. It is hypothesized that the crud was converted into a more mobile material while on HWC, was distributed around the primary system, and then cleaned up after the switch back to oxygenated chemistry. This reactor has gone back to HWC and will continue to monitor the dose rates to establish whether the hydrogen effect is transient or a continuing concern.

Two other plants introduced hydrogen injection at about the same time as they implemented zinc injection. The first plant introduced hydrogen and zinc simultaneously in 1989. During the ensuing two cycles, dose rates at the standard locations were about 120 mR/h. At other locations around the drywell, localized hot spots were found early, pointing to a mobile insoluble transport mechanism as opposed to the soluble incorporation mechanism usually dominant in BWR radiation buildup. As operation has continued, the hot spots have diminished, contributing to the hypothesis that the problem is of a transient nature. The second plant to implement both hydrogen and zinc injection started adding hydrogen one half cycle before zinc. Dose rates immediately increased from around 500 mR/h to 750 mR/h. Following end of cycle decontamination, dose rates during the next cycle rose rapidly to about 600 mR/h. Another chemical decontamination was performed at the end of this cycle. Currently, in the second full cycle of injecting both hydrogen and zinc, the rate of buildup is still quite high. While Co-60 buildup is lower, high levels of Zn-65 have been observed. As a benefit of adding zinc, the reactor water soluble Co-60 has decreased by a factor of about three and thus corrosion film buildup is believed to be low. If verified, this would support insoluble deposition transport and deposition as the probable cause of the high dose rates. Even taking into account the potential dose rate impact described here, HWC continues to be recommended as the most effective approach to protecting reactor piping and vessel internals from stress corrosion cracking (SCC) and the resulting costs in both person-rem and dollars, which can occur.

Taken from, "Looking for Links Between BWR Hydrogen Water Chemistry and Increased Shutdown Dose Rates," William J. Marble, Robert L. Cowan, and Christopher J. Wood, Nuclear Engineering International, October 1992, p. 42.