N218. How Hydrogen Water Chemistry Impacts Shutdown Dose Rates in BWRs

Starting in early 1992, EPRI initiated a program to investigate the causes of drywell dose rate increases associated with implementation of hydrogen water chemistry (HWC) and develop mitigation techniques to minimize their impact. The first phase of this program has identified the apparent underlying cause but has not yet fully defined the transport and deposition mechanisms.
When the chemical environment is changed by injecting hydrogen, the stable form of the oxides present in the plant changes from the hematite 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 soluble phase mechanisms can contribute, transport and deposition of the insoluble phase isotopes is believed to be most responsible for the increased dose rates.
At one plant, which had an early history of high crud input, the switch to HWC caused the radiation fields at standard measurement locations to increase from approximately 250 mR/hr to 900 mR/hr. Switching back to normal water chemistry (NWC) in mid-cycle resulted in dose rates near normal during the refueling outage. Inspection of the annulus area of the reactor during the outage showed that crud accumulations which had been observed there previously from the high crud input period, had now disappeared. It is hypothesized that this crud was converted into a more mobile material while on HWC, had been distributed around the primary system and then was cleaned up after the switch to NWC. Plant personnel have reinitiated HWC and will monitor the dose rates at each opportunity to determine if the hydrogen effect is transient (and therefore complete) or is an ongoing concern. Two other plants implemented HWC at approximately the same time as implementing zinc injection. The first plant used HWC and zinc simultaneously in 1989. During the ensuing two cycles, dose rates at the standard locations were relatively low at approximately 120 mR/hr. At other locations around the drywell, hot spots were identified, indicating a mobile insoluble incorporation mechanism as opposed to the soluble incorporation usually dominant in BWR radiation buildup. As operation continued, the hot spots diminished. This observation contributes to the hypothesis that the problem is of a transient nature.
The second plant to implement HWC and zinc injection started adding hydrogen one half cycle before zinc. Dose rates immediately increased from approximately 500 mR/hr to 750 mR/hr. 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 high. While the Co-60 buildup is lower, unexpectedly high levels of Zn-65 have been observed. With zinc, the reactor water soluble Co-60 decreased by a factor of approximately three, thus corrosion film buildup is believed to be low. This again supports the insoluble deposition transport and deposition as the probable cause of the high dose rates.
Even considering the potential dose rate impact, HWC continues to be recommended as the most effective approach to protecting reactor piping and vessel internals from stress corrosion cracking and the resulting costs, in both person-rem and dollars, which can occur.

Taken from, "Switch to HWC Impacting Shutdown Dose Rates in BWRs," Bill Marble, Bob Cowan, and Chris Wood. Radiation Control News, No. 15, September 1992. (EPRI, 3412 Hillview Avenue, Palo Alto, CA 94303).