Diablo Canyon Power Plant is a two unit Westinghouse pressurized water, nuclear reactor plant, with main condenser cooling provided by seawater. Seawater cooling makes the units extremely sensitive to ultra-trace condenser leaks and has necessitated the on-going use of full flow mixed bed condensate polishers to maintain the required levels of steam generator water purity. The plant uses the organic amine, ETA, as the neutralizing amine in the steam water circuit to provide additional protection against Flow Assisted Corrosion (FAC) and minimize iron transport to the recirculating steam generators. This has been the preferred practice for many PWR plants of this type when condensate polishers are employed.

**The problem**

Rapid kinetic impairment of the anion resin has been a common experience for plants running ETA chemistry with mixed bed condensate polishers not having upstream cation resin beds. The kinetic degradation leads to increased sulfate concentrations in the steam generator. The exact mechanism by which the ETA related fouling occurs is not well understood, and has only been managed by hot water rinsing of the anion resin and partial change out of the polisher beds with new anion resin. There has been no proven method for prevention of the ETA related fouling.
Following a full system resin replacement in 2006, Diablo Canyon also experienced the common symptoms of ETA related problems. These symptoms include reduced anion resin kinetics as measured by Mass Transfer Coefficient (MTC), and increased sulfate concentration in steam generators. Figure 1 shows the sulfate concentrations in the steam generator during the emergence of this problem.

Further investigations also discovered that the principle source of the additional sulfate in the steam generators was the extended rinse of ionic sulfate, and elevated effluent sulfate concentration coming from the mixed beds immediately following regenerations (Hoffman 19). The extended rinse and degraded bed effluent quality were a direct result of the reduced anion resin kinetics. See Figure 2.

During the following months, Diablo Canyon continued to manage the sulfate problem by on-going measurement of anion resin MTC, hot water rinsing of the anion resin, and occasional partial exchange of anion resin from the mixed beds with fresh anion resin. Although these efforts were somewhat successful, they placed extra burdens on plant staff. Without these efforts, MTC values would degrade below 1.5 x 10^4 m/s, and steam generator sulfate concentrations would become unacceptable.

**Testing a new solution**

While the exact mechanism causing the degradation of anion kinetics remained unknown, the Dow Water and Process Solutions technical support team, working with the customer, continued efforts to gain understanding of the root cause issues. This ultimately led to an idea for a product change that would
provide a more permanent solution to the kinetic degradation caused by the use of ETA in standalone mixed bed condensate polishers. In March of 2010, a test bed of a new cation resin (that would later be called DOWEX™ MONOSPHERE™ 1400PC) combined with AMBERJET™ 9000 OH anion resin, was installed at Diablo Canyon. The plan for the test bed was to minimize cross-mixing of this test bed resin with all other mixed beds during operation, in order to develop an accurate data record of its anion kinetics (MTC) over an extended period of time. The sulfate effluent performance of the bed was also monitored.

The sulfate rinse and effluent performance of the test bed remained excellent for nearly two years following its installation, without any special efforts such as hot water rinsing or anion resin partial exchange. This was supported by regular periodic kinetic testing of the anion resin in the test bed. Figure 3 below shows the excellent kinetic stability of the anion resin in this test bed over time. The kinetic performance of the test bed was far better than the on-going kinetic degradation that was seen in all other beds. By the end of the two year test period, a slight decrease in the anion resin MTC was observed for the test bed. This reduction in anion MTC was due to the inevitable intermixing of the test bed resin with resin from the other mixed beds within the polishing system during resin regeneration and transfers.

**Conclusions**

A test bed of DOWEX MONOSPHERE 1400PC cation resin combined with AMBERJET 9000 OH anion resin was able to maintain stable, acceptable anion resin kinetics (MTC) and sulfate effluent performance in a PWR mixed bed condensate polisher where ETA was used as the neutralizing amine. This was accomplished without the need for special hot water rinsing or top-up of resin in the test bed. The new cation resin, DOWEX MONOSPHERE 1400PC, provides a significant new tool to help facilitate sustainable full flow condensate polisher operation in PWR plants using ETA chemistry. DOWEX MONOSPHERE 1400PC cation resin is fully compatible with proven Dow condensate grade anion resins such as DOWEX MONOSPHERE 550A and AMBERJET 9000 OH.

A great appreciation is owed to the team at Diablo Canyon for their desire to solve the issue of anion kinetic impairment associated with using ETA and their willingness to collect meaningful data throughout this effort.
References:


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