Ion Exchange:

The Dominion Engineering Millstone Nuclear Power Station is located on a peninsula at the eastern end of Long Island Sound. (Photo courtesy of the Dominion Engineering Millstone Nuclear Power Station)

Nuclear Plant Improves Efficiency and Water Quality with New Gel Resins

By Stephen W. Najmy

Summary: *New ion exchange resins and procedure modifications for regenerating and remixing resin enabled one nuclear power station to significantly improve performance in water quality and operational efficiency of deep-bed condensate polishers. Modifications to its cycle chemistry program also allowed for 75 percent less blowdown.*

The Dominion Engineering Millstone Station is a pressurized water reactor (PWR) nuclear power plant in Waterford, Conn., that relies on its deep-bed condensate polishing systems to help control secondary cycle steam generator chemistry in Units 2 and 3.

In this application, the mixed bed condensate polishers are designed to:

- Protect the steam generators in the event of a condenser tube failure,
- Allow 100 percent power operation during periods of low level sea water ingress, and
- Filter corrosion products transported from the main condenser.

The Millstone Station decided to use two types of resins specially targeted at nuclear water applications in their fullflow condensate polishing systems to optimize water quality and operational efficiency. One is a uniform particle size (UPS) strong base Type 1 anion resin for non-regenerable demineralizers, with a quaternary amine functional group. The other is a UPS strong acid cation resin for demineralization, with a sulfonic acid functional group. Both are styrene-divinylbenzene (DVB) gel-based resins.

Background

Millstone 1, which began commercial operation in 1970, ceased generation in November 1995 and was closed in 1998. Millstone 2, which became operable in 1975, has a net capacity of 873 megawatts (MW). Millstone 3, which became operable in 1986, has a net capacity of 1,137 MW and is the fifth largest nuclear reactor by gross generation in the United States and the 13th largest in the world, with 10,542,503 megawatt hours generated (MWh) in 2000. By gross generating capacity (99.35 percent), Millstone 3 ranked as 15th largest in the world and 11th largest in the United States in 2000.'

Prior to 1990, the Unit 2 steam generators experienced serious tube degradation by a variety of corrosion-related mechanisms. These mechanisms resulted in denting, pitting, intergranular attack and intergranular stress corrosion cracking. This eventually necessitated replacement of the steam generators in 1992 at great expense to the station's utility owner.

To maintain material integrity of the new steam generators and the balance of plant components, Millstone 2 implemented the following changes to the secondary cycle chemistry program:

- Replace ammonia with enthanolamine as the secondary cycle pH-control additive beginning in April 1993,
- Increase the hydrazine feed rate to attain an 8:1 concentration ratio of final feed water hydrazine to condensate dissolved oxygen, and
- Operate with full-flow condensate polishing and only in the hydrogen cycle (terminate the service cycle at the amine break).

Ethanolamine reduces the potential for two-phase erosion-corrosion in the heater drains and other wetted steam areas of the plant. So, the expectation of this new chemistry was to significantly reduce the amount of insoluble impurities in the final feed water. Once the switch was made to ethanolamine, the impact on the final feed water iron for Millstone Unit 2 was an immediate step change improvement from a range of 8 to 10 parts per billion (ppb) to a range of 2 to 3 ppb.