DOWEX Ion Exchange Resins

Less-Separable Mixture of DOWEX Resins Brings Iron and Sulfate Under Control

Site Information

Location

Massachusetts, USA

Purpose

- Reduce feed water iron to below 2.1 ppb
- Maintain reactor water sulfate to below 2.0 ppb

Comparative Performance

Feed water iron remains consistently below 2.0 ppb and reactor water sulfate below 1.5 ppb without upstream prefilter system.

Entergy Corporation's Pilgrim Station used DOWEX ion exchange resins to lower its Chemistry Index and reduce the ingress of impurities to its reactor vessel. (Photo courtesy of the Entergy Corporation Pilgrim Nuclear Power Station, Paul Nehrenz, Photographer)*

Introduction

Entergy Corporation's Pilgrim Station in Massachusetts is a boiling water reactor (BWR) nuclear power plant that relies on its deep-bed condensate polisher to help control primary cycle chemistry and protect the downstream reactor system. Because Pilgrim does not have an upstream prefilter system, the station relies on the mixed ion exchange resin in the condensate polisher vessels to remove both ionic and particulate (insoluble iron) species from the condensate return stream.

Entergy Corporation acquired the Pilgrim Station in July 1999 and immediately challenged the station to improve its Chemistry Index. To achieve this, Pilgrim would need to reduce feed water iron and reactor water sulfates. One key solution was to replace the current ion exchange resins with a mixture of DOWEX* MONOSPHERE* 575C cation resin and DOWEX SBR-C anion resin.

Sources and Effects of Iron Contamination

In a BWR nuclear power plant, excessive amounts of insoluble iron in the feed water can cause two major problems:

- **Heat transfer reduction**. Iron buildup on the cladding of the nuclear fuel reduces heat-transfer efficiency and can lead to nuclear fuel cladding failures.
- **Shutdown dose rates.** Non-optimal levels of iron in the feed water affect the transport of activated corrosion products, increasing radiation dose rate on the reactor piping and increasing worker exposure.

In addition, the accumulation of insoluble iron (crud) deposits in combination with contaminant ions, such as sodium, chloride, and sulfate, creates conditions conducive to intergranular stress corrosion cracking (IGSCC) of BWR pressure vessels and reactor internals.

Sources and Effects of Sulfate Contamination

Reactor water sulfate can come from one or more of the following sources:

- Ionic sulfate not removed by the condensate polisher anion exchange resin during conditions of condenser in-leakage
- Ionic and organically bound sulfate from thermodynamic degradation of the cation exchange resin in the condensate polisher and reactor water clean-up vessels
- Cation exchange resin fines that are sufficiently small to pass through the screened under-drain laterals of the condensate polisher vessels

A key part of determining the most cost-effective solution is to understand which of these sources is controlling reactor water sulfate levels. For most situations the answer is the presence of organically bound sulfate in the polisher effluent stream.

Although sulfate is a natural decomposition product of the cation resin, the anion exchange resin readily adsorbs any sulfate and low molecular weight organic sulfonates from this source. However, cation resins are denser than anion resins, and during the transfer of the mixed resins back to the service vessel, a cation resin “heel” can form at the bottom of the vessel. Consequently, sulfate species that leach from the cation resin can move downstream and concentrate in the reactor water system.

Solution: Less-Separable Resins

A common approach for better control of feed water iron and reactor water sulfate contamination involves a retrofit of the condensate polisher system with a non-precoat filter system. However, some BWR stations cannot justify this expense, estimated between $4 and $10 million.

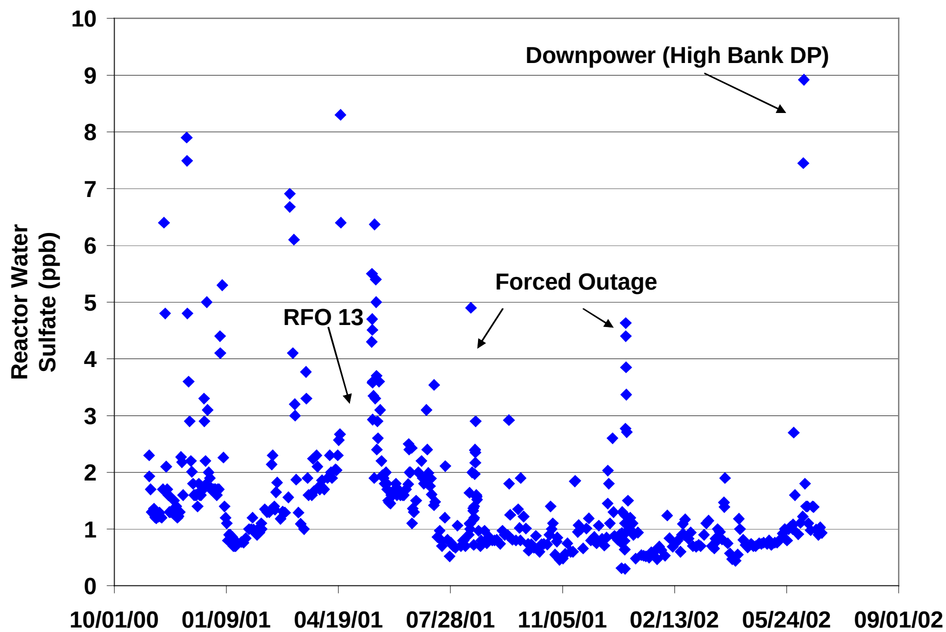
Another solution is to replace the existing ion exchange resins with a mixture of less-separable resins, in this case, DOWEX MONOSPHERE 575C cation and DOWEX SBR-C anion resins. This resin combination was selected because of performance advantages demonstrated from installations at the Oyster Creek BWR nuclear power station. The differentiated performance for the less-separable DOWEX mixed resin is attributed to:

- Reduced separability compared to standard resin mixtures (less tendency for resins to classify, translating to reduced sulfate leakage)
- Smaller cation resin bead diameter (550 µm) with uniform size distribution (an increase in the total surface area of the cation resin, providing better crud filtration)

New Resin Bed Installation

Prior to the fall of 2000, Pilgrim Station experienced difficulty in controlling reactor water sulfate. Typical levels ranged between 1 and 3 ppb with periodic excursions up to 4 ppb and higher (see Figure 1). At the time, all of the condensate polisher vessels contained a 1:1 equivalent ratio of DOWEX HGR-W2 and SBR-C resins. Beginning in the fall of 2000, Pilgrim Station replaced three of their resin beds with the less-separable combination of DOWEX MONOSPHERE 575C cation and DOWEX SBR-C anion resins.

Figure 1. Reactor water sulfate trends at the Pilgrim Nuclear Power Station.



In the spring of 2001, the remaining four beds were also replaced with the less-separable DOWEX resin combination. In addition, the resin-transfer procedures incorporated an anion resin underlay, and the station installed new under-drain laterals. These new laterals were constructed with a higher strength design to alleviate pressure drop issues and improve resin transfer capability.

The impact of these improvements, including the new resin beds, on reactor water sulfate control is easily illustrated by Figure 1. Following the start-up from the refueling outage (RFO 13) in the spring of 2001, the reactor water sulfate levels stabilized down to a range of 0.5 to 1.5 ppb. Since that time, reactor water sulfate control has continued to improve and remains steady in the range of 0.5 to 1 ppb.

The impact on feed water iron is shown in Figure 2. Feed water iron control began to improve following RFO 12 in the summer of 1999. This improvement resulted from modifications to the resin cleaning protocol. Since that time feed water iron control has remained stable in the range of 1 to 2 ppb. Currently, Pilgrim operates with all seven beds of the less-separable DOWEX MONOSPHERE 575C and SBR-C mixed resin in their condensate polisher vessels.

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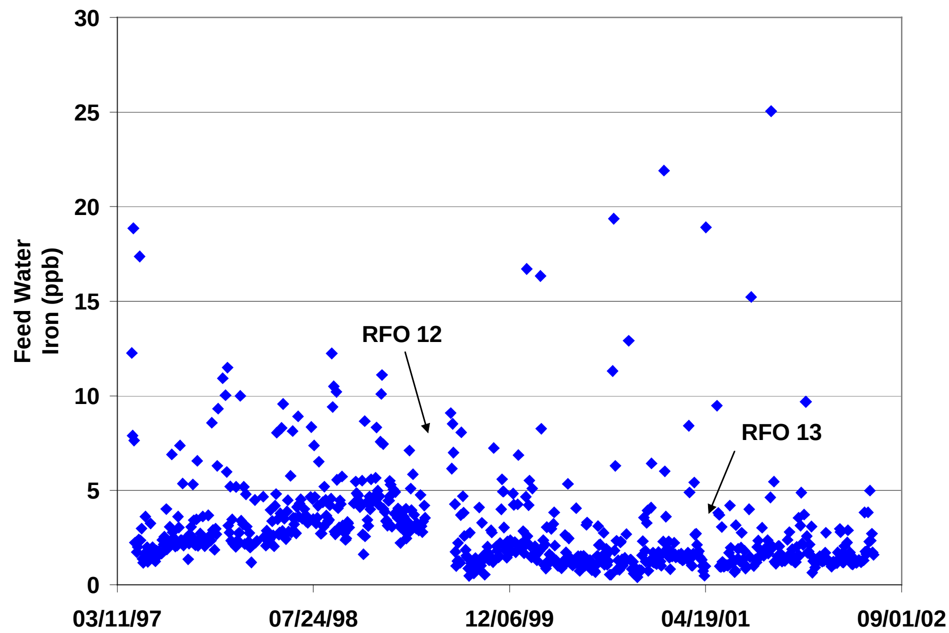
Figure 2. Feed water iron trends at the Pilgrim Nuclear Power Station.



Conclusions

Entergy's Pilgrim Nuclear Power Station now operates with seven beds of the less-separable DOWEX MONOSPHERE 575C and SBR-C mixed ion exchange resin. Since the installation of this new resin 24 months ago, feed water iron remains consistently below 2.0 ppb and reactor water sulfate below 1.5 ppb. Even without the benefit of an upstream prefilter system, the switch to the new condensate polisher resin has aided Pilgrim in lowering its Chemistry Index and reducing the ingress of impurities to its reactor vessel.

DOWEX Ion Exchange Resins
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