Micro Media Filtration Proving Effective in Produced Water Softening Systems

Contributed by Eco-Tec

Having an effective, durable pretreatment system in advance of ion exchange produced-water softening systems is the first, most critical line of defense – ensuring smooth, more trouble-free performance downstream.

It's especially true when dealing with today's ion exchange technologies, which require TSS (total suspended solids) of 0.1-0.5 mg/L and turbidities of 0.1-1 NTU (nephelometric turbidity units). Most suppliers of ion exchange resin would advise removal of suspended solids to at least 1 mg/l or better through some form of pretreatment and that some, but not all, of the residual solids that accumulate within resin beds be removed by periodic backwashing of the resin. If allowed to accumulate, these solids can adversely impact water and regenerant chemical distribution, will ultimately increase pressure drop, and degrade water quality and quantity. Furthermore, longer term fouling by solids and residual oil can make subsequent resin cleaning much more difficult, if not impossible.

With the ongoing trend towards packed bed ion exchange systems, the sensitivity to solids fouling has increased even more. In these systems there is little or no freeboard space within the resin column making it much more difficult and, in some cases, impossible to backwash the resin to remove the accumulated dirt. This means resin must routinely be removed from the column and washed, with typical cleanings reported to be one to two times per year.

What Makes Sense?

So what makes the most sense, given the various options available? There is of course no such thing as a standard pretreatment process. In the past, the most prevalent ion exchange pretreatment options have been direct (depth) media filtration using a layer of granular media such as sand, and/or anthracite with coagulation. Due to its low cost and simple and reliable operation, granular media filtration has historically been amongst the most common of pretreatment methods.

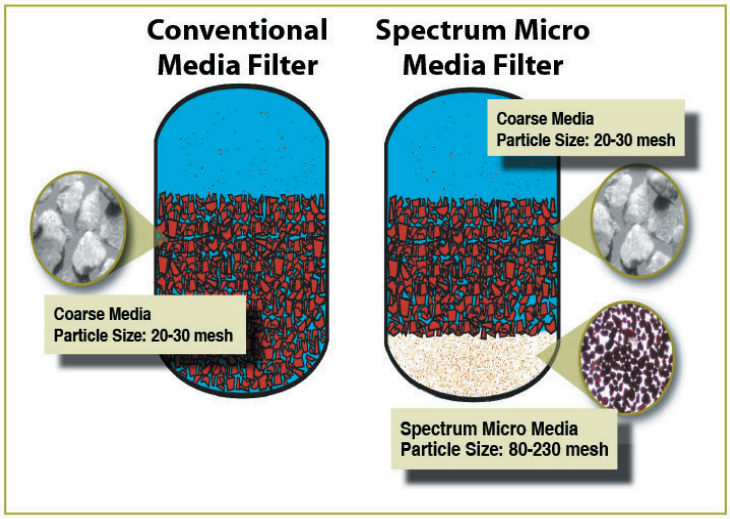
Spectrum Plus Micro Media Filters for a heavy oil operation in Bakersfield, California.

However, conventional media filtration is best at removing materials down to 10-20 microns (µm), and if evaluations indicate solids smaller than 10 µm, supplemental filtration should be considered.

Multimedia filtration, which utilizes two or more different media as opposed to one, is a step up and

provides improved performance. In many instances, however, consistent operation is somewhat difficult to obtain because of the typical 'ripening' period these filters undergo when they are first put into service after a backwash, during which time water quality is inferior. Moreover, while the filtrate quality tends to improve as the cycle proceeds, termination of the cycle normally sees an increased pressure drop accompanied by a breakthrough or leakage of turbidity.

As an alternative to media filters, microfiltration and ultrafiltration membranes provide further improved performance. Essentially, they provide a membrane barrier to total suspended solids (TSS) and ensure consistently low levels of TSS to downstream processes.



However, such systems also come with a number of challenges. Membranes will foul and systems need to be designed with regular backflow mechanical cleaning as well as periodic chemical cleaning. Also, while the performance of a single membrane element may be excellent, the performance of a system consisting of thousands of such elements is only as good as management of the broken filter elements and maintenance of seals. Finally such systems typically come with a higher initial cost and must account for periodic membrane replacement costs.

Striking a Balance

Considering the various positives and negatives behind today's pretreatment options, striking a strong balance makes sense – in other words, maintaining the low capital and operating cost of conventional dual media filters while addressing limitations and boosting filtration efficiency to levels once only achievable with membranes.

In recent years, multi-media filtration has advanced considerably – now boasting superior filtration relative to conventional media filters and filtration efficiency approaching levels similar to ultra filters and micro filters.

Combining greater filtration efficiency with the durable – basically indestructible – nature of media filtration means a significant reduction in cleanings, overall downtime, and many other related costs for plants.

For several years, design and manufacturing firm Eco-Tec, Inc. has been delivering a strong prefiltration solution through its advanced media configuration known as Spectrum Micro Media, basically a two-layer depth media filter with a number of features that depart from conventional designs; namely, a coarse media (either anthracite or nutshells) upper layer, a fine micro-media lower layer, and high service flow rates.

The lower, fine micro-media layer is the key feature compared to conventional designs. While dual media filters typically employ silica sand with an effective size of about 0.35 mm, the Spectrum filter uses a lower layer of high density media with an effective size of less than 0.1 mm.

The flow channels through the micro media are extremely small and the tortuous path of fine channels provides excellent retention of solids. It is much heavier in density than coarse media which ensures that it reclassifies (resettles below the coarse media after backwashing) and is virtually impossible to backwash out of the filter vessel.

The top layer consists of coarse anthracite – similar to, but somewhat finer than that used in conventional dual media filters – and provides the bulk of the solids retention and therefore defines the run length.

Proven Field Results – Liaohe Oilfield, China

An instance where micro media filtration can be seen working effectively in advance of produced-water softening is at the Liaohe Oilfield, Liaoning province, in northeast China. It's the largest heavy oil production field in China with 10,000 oil wells and a production capacity of 250,000 BPD (12,500,000 T/year). Using a steam stimulation process, the oilfields produce 20,000 m^3/day of produced water. The oilfield required a produced water purification system to provide water quality suitable for feed water to the high pressure, once-through steam generators.

The strict treatment target requirements, specified by the Chinese National Industrial Standards, required the oilfield to maintain boiler feed of <2 mg/l oil, <2 mg/l TSS and <0.1 mg/l hardness (as $CaCO_3$). In addition to the standards required, other factors were taken into consideration for the design such as fluctuating flow rates in both TSS levels and oil levels.

After failed attempts with other produced water processes, a Liaohe delegation visited Canada to explore the latest technology for produced water. Eco-Tec designed and proposed a system to address the needs, and guidelines, specified by Liaohe officials. Through the minimization of risk, adherence to quality requirements, providing reliability and adaptability to fluctuations, and utilization of advanced technology and instrumentation, Eco-Tec has successfully implemented a large-scale produced water treatment system for heavy oil production.

The produced water treatment system was designed to include components including a dissolved air flotation (DAF) process, a clarifier, walnut shell filters, followed by a train of eight Spectrum Micro Media Filters (2.74 metres/108 inches in diameter) and completing the process with 11 of Eco-Tec's Recoflo WAC Ion Exchange Softeners (4 metres/157 inches in diameter).

It was not felt that the walnut shell filters were capable of achieving the final 2 mg/L limits for oil and TSS. The Spectrum Micro Media filters were designed to act as polishing filters to help achieve the ultimate goal of 0.1 mg/L hardness.

The Eco-Tec process for treating and reusing produced wastewater has been in continuous operation at the Liaohe Oil Field and is performing consistently. The aggressive project schedule as well as the mandatory performance requirements for TSS, oil, and hardness removal have all been achieved. All of the sludge generated by the process has been effectively treated and re-used as supplemental fuel.

Overall, the system has proven reliable, simple to operate, and requiring minimal maintenance and operator attention. The DAF units remove the bulk of the TSS and oil and the Spectrum Micro Media Filters achieve final effluent limits; both are key elements in the flow-sheet, ensuring the success of this project.

Compared to conventional walnut shell filters, which alone do not reliably meet performance requirements, the Spectrum Micro Media Filters have fulfilled their role and consistently meet the final effluent requirements of 2 mg/L for TSS and oil. The average concentration of oil and TSS in the feed-water to steam generators is 0.8 mg/L and 0.3 mg/L, respectively. Even when the concentration of TSS in the feed exceeded 300 mg/L, the allowable maximums of 2 mg/L were not exceeded. Largely because of the excellent pre-treatment by the

Micro Media Filters for the Liaohe Oilfield in China.

Spectrum Micro Media Filters, the WAC ion exchange softeners have consistently been able to achieve hardness leakage levels below the limit of detection.

Proven Field Results – Seneca Resources, Lost Hills, California

Another recent example illustrating the value of Spectrum Micro Media Filters can be found at Seneca Resources Corporation's plant in Lost Hills, California, where its once-through steam generator (OTSG) produces 70 per cent steam at 800 psig using fresh water. Seneca is the oil and gas exploration and production segment of National Fuel Gas Company, and develops natural gas and oil reserves in the California and the Marcellus Shale.

Produced Water Treatment System for Seneca Resources, featuring Spectrum Micro Media Filter in advance of ion-exchange softeners.

When California began enduring severe drought in 2008, it became even more challenging to extract heavy oil using steam generated from fresh water sources. Governor Arnold Schwarzenegger, in an effort to manage the crisis, proclaimed a state of emergency and put forth widespread water-conservation measures.

As a result, Seneca Resources found it could no longer practically obtain the 7,000 bpd of fresh water it needed. The company was denied fresh California-aqueduct water from the Lost Hills Water District and, instead, had to resort to purchasing its supply from farmers in the area. According to Seneca, "It made practical and economic sense to get off fresh water and move to produced water to produce steam."

Seneca's interest was peaked by Eco-Tec's unique Spectrum Micro Media Filter and the compact RecoPur Ion Exchanger (IX) Softeners. In particular, pretreatment with the Spectrum Filter would effectively polish out the free oils and solids, eliminating the many problems related to downstream softener fouling. The updated Eco-Tec system would effectively remove the oil and suspended solids and then soften the high hardness (446.7 mg/L as $CaCO_3$) or high total dissolved solids (7,100.3 mg/L) that make up the produced water, at about 7,000 bpd.

For Seneca, the specialty Spectrum micro-media filter operates after an Induced Gas Floatation (IGF), and in advance of Eco-Tec's skid mounted, short bed 'Recoflo' Strong Acid Cation (SAC) and Weak Acid Cation (WAC) salt-regenerated ion-exchange softener.

The oil and suspended solids levels in the feed are typically < 3mg/L (upsets to as high as 70 mg/L), and <10 mg/L (upsets to 70 mg/L), respectively. To avoid fouling of the downstream softener, oil and suspended solids must be reduced to <0.1 mg/L. To produce the required softened water product flow of 7,000 bpd, a single 60-inch diameter Spectrum filter was selected.

The updated system at Seneca has performed consistently to the time of publishing this article. A water hardness level of <1 ppm has been maintained, and additional field samples reveal product hardness levels of 0.2, 0.33, and <0.13 ppm. And softener resin cleaning, as a result of resin fouling by oil and suspended solids, has not been needed in more than 20 months since the system has started up; this is mainly attributed to the Spectrum Micro Media Filter's ability to effectively polish out the free oils and solids.

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