SORB 33® Arsenic Removal Systems
Adsorption Chemistry and Process Description

SEVERN TRENT SERVICES

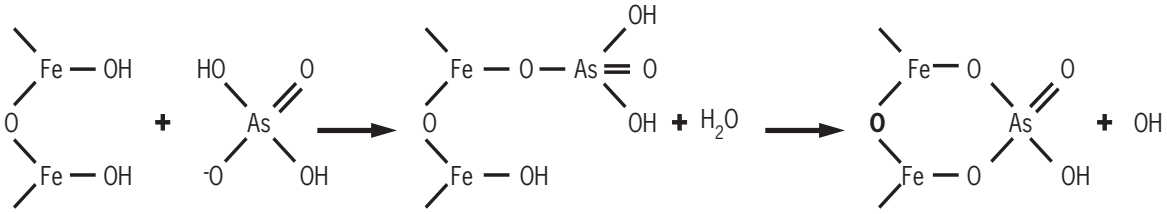
Filtration Products

Arsenic Adsorption Chemistry

Severn Trent Services' SORB 33® Arsenic Removal Process is a fixed bed adsorption system using a granular ferric oxide media, or adsorbent, called Bayoxide® E33 as a pelletized ferric oxide media called Bayoxide® E33-P for the adsorption of dissolved arsenic onto the ferric oxide. It employs a simple **"Pump & Treat"** process that flows pressurized well water through a fixed bed pressure vessel containing the media where the arsenic removal occurs.

In the SORB 33® Process, both As(III) and As(V) oxyanions are removed from water via a combination of adsorption, occlusion (adhesion) or solid-solution formation by reaction with ferric oxide ions. Above pH 7, the primary mechanism is adsorption of the oxyanions to the surface hydroxyl groups of ferric oxide hydroxide as indicated below:

As(V) Adsorption Reaction with Bayoxide® E33 or E33-P



a-FeOOH **Arsenate**

Adsorption is a continuous process conducted at a specific flow rate or velocity, normally about 7 gpm/ft2, downward through the fixed bed adsorber for operating periods of about 1 month on stream duration. In addition to velocity, the other key process parameter is empty bed contact time (EBCT). This is the variable which dictates the amount of water contact time within the bed required to effect complete arsenic adsorption; the normal design value is 4 minutes.

The media adsorbs As(V) with rapid kinetics (adsorption). Unlike most other adsorbents, it will also adsorb As(III). Arsenite is nonionic at normal water pH's, and therefore, it will not be adsorbed as an anion. Adsorption kinetics for As(III) are slower than that of As(V), probably because it is first oxidized by the media before it is adsorbed.

Prechlorination for oxidation purposes is recommended for water sources with As(III) which also have elevated iron levels (over 150 µg/L Fe). Oxidation ensures efficient arsenic removal as As(V) along with co removal of iron. Another benefit is that some arsenic is adsorbed onto the iron oxide precipitate and removed, thus extending the media's arsenic capacity.

Process Description

Arsenic adsorption is a simple treatment process. Flow is downward through a pressure vessel containing the Bayoxide® E33 media. The adsorbers can be operated for extended periods of time (weeks or possibly months) before they are taken out of service for backwashing media.

Once every 1-4 months depending upon the water's quality, each adsorber is taken out of service for backwashing, or fluffing, to expand the compacted media bed and to remove solids that may have built up within the bed. Aside from this, there is no other non-service action required until the end of the pilot program or when the media is exhausted.

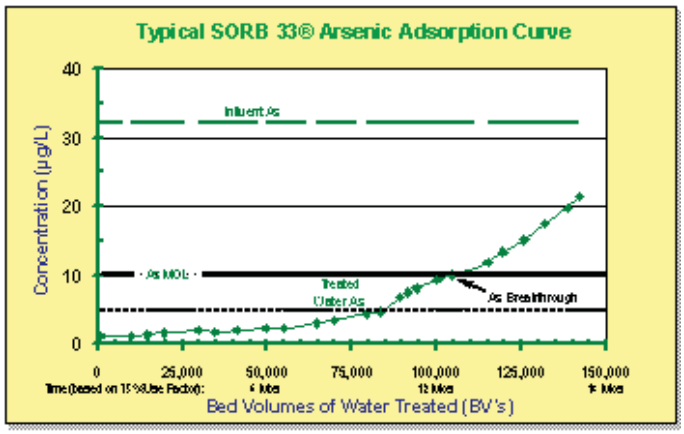
Media life ranges from 6 months to 6 years depending upon the system's utilization factor (on stream time), on the influent water's arsenic level, and the presence and concentration of other ions in the water that could shorten the media's arsenic adsorption capacity.

The pressure differential (ΔP) through each adsorber is monitored. When the ΔP on either adsorber exceeds the high ΔP setpoint (normally 10 psi), that adsorber is automatically taken off line and backwashed using well water. After the 12 minute backwash, the adsorber is returned to service.

Arsenic Adsorption Performance

Arsenic Removal performance via adsorption is illustrated graphically using a "Breakthrough Curve" such as the one shown below. Performance of an adsorbent is measured by the number of bed volumes of water that can be treated with one bed volume (BV's) of media before it exhausts, i.e. can no longer adsorb arsenic efficiently. The adsorption curve below is typical for Bayoxide® E33 media used in the SORB 33® Process. In this case, water containing 32 µg/L arsenic can be treated to about 105,000 Bed Volume's before the treated water's arsenic level exceeds the MCL of 10 µg/L. This is called the breakthrough point.

Monitoring of SORB 33® performance is done by routine analysis of the treated water. Initially, this can be done on a monthly basis. As the treated water arsenic level increases, this frequency is increased to semi-monthly so as to be able to schedule media replacement as close to the breakthrough point as possible without exceeding the MCL. In this case, more frequent analysis starts at about 80,000 BV's when the arsenic increases about 4-5 µg/L. Using the timeline, this would be at about 9½ months, and the analysis is closely monitored until the media is changed out at about 98,000 BV's, or after 12 months of operation, when the treated water arsenic reaches 9 µg/L.

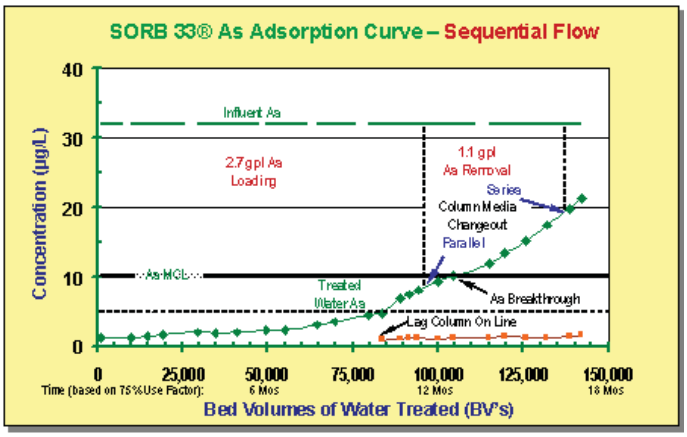


Sequencing Flow Configuration

Unlike breakthrough curves for water softening resins or some other adsorbents, arsenic will continue to be adsorbed even after it exceeds the MCL. Softening resin breakthrough curves breakthrough rapidly to the influent levels (within <1,000 BV's on the above curve) leaving little time to schedule media change-out, etc. However, in the illustration above, arsenic continues to be adsorbed from partially "spent" Bayoxide E33 media for over 20,000 BV's after the 10 µg/L breakthrough point.

The advantage of an "extended adsorption" media like Bayoxide E33 is that its arsenic capacity can be increased in a lead/lag series, or "sequencing" flow configuration. Effluent water from the primary, or "lead", column can contain as much as 15-20 µg/L arsenic because this partially treated water is further treated in a "lag", or polishing, column where the final arsenic level is reduced to <3 µg/L. The net result of this flow configuration is an increase in the media's adsorption capacity of 15-40%. This increase translates into a proportional reduction in operating costs. The second arsenic adsorption curve below depicts the effect of sequential flow configuration.

Using the same water quality and other conditions as described above, the lead SORB 33® column is operated in parallel flow (delivering treated water) through 84,000 BV's when its treated water's arsenic level reaches 5 µg/L. At that time, a lag column is valved in to receive the lead adsorber's effluent water. The treated water now contains less arsenic (1 µg/L) than before. If the lead adsorber was in parallel configuration and taken off line at 98,000 BV's, the Bayoxide E33 would have adsorbed 2.7 grams arsenic per liter (gpl) of media. In the sequential flow con-figuration, the media treats an additional 41,000 BV's, adsorbing an additional 1.1 gpl arsenic until its effluent contains 19 µg/L arsenic. The lag column removes the remainder of the water's arsenic producing a water quality below 2 µg/L arsenic. In this example, the Bayoxide E33 media treated an additional 42% water volume and adsorbed an additional 29% arsenic.



With the lead column out of service for media changeout, the lag column is operated in parallel flow configuration until its effluent arsenic level reaches 5 µg/L and is then placed into lead position with a lag column behind it. It will operate in the parallel flow mode for an additional 35,000 BV's before sequencing is required.

Design improvements may be made without notice.

Represented by:

SEVERN TRENT SERVICES

Severn Trent Services
5415 W. Sligh Avenue, Suite 102
Tampa, FL 33634
Tel 813 886 9331
Toll 800 364 3931
Fax 813 886 0651
info@severntrentservices.com
www.severntrentservices.com