ARSENIC

REMOVAL

LEWATIT® FO 36

Ion Exchange / Iron Oxide Hybrid System

LEWATIT®
ION EXCHANGE RESINS

LANXESS
Energizing Chemistry

LEWATIT® FO 36

THIS NEW ION EXCHANGE RESIN FOR SELECTIVE ARSENIC ADSORPTION MAKES POTABLE WATER SAFE TO DRINK.

APPLICATION AREA

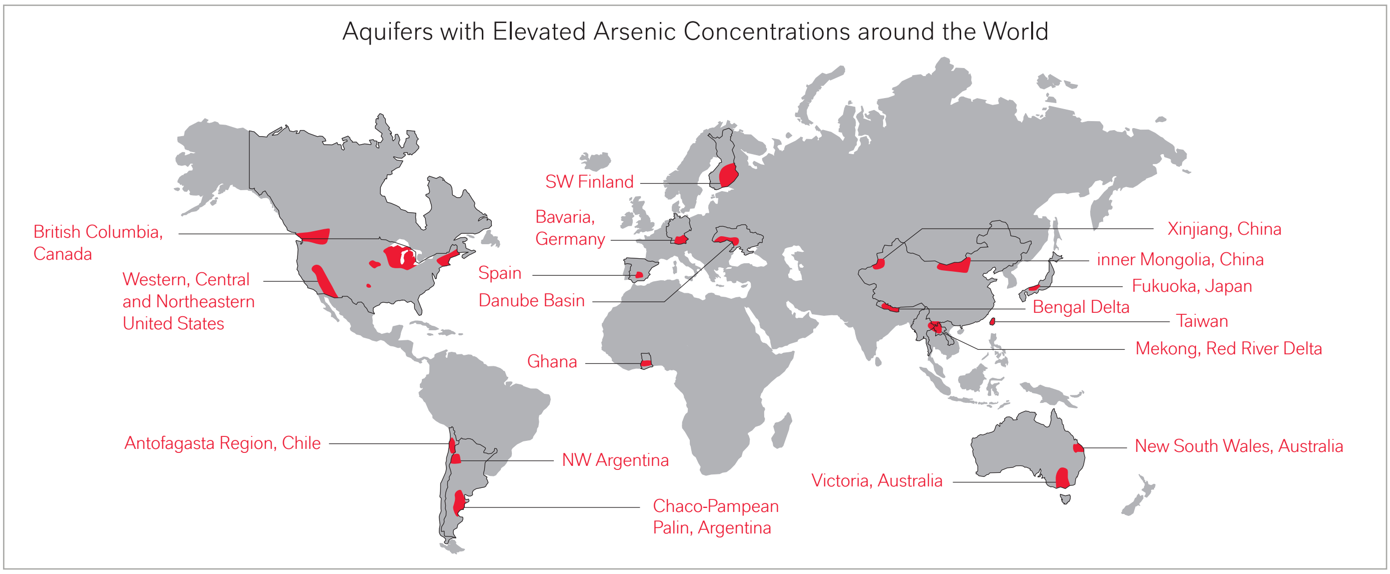
Arsenic contamination in potable water supplies has become a major issue in respect to human health. Arsenic in water originates from both, natural sources (geological erosion), as well as man-made pollution (mining operations that contaminate ground waters). The concentration of arsenic may reach up to 1,500 ppb in certain areas. Arsenic is known to cause damage to human health; the World Health Organization (WHO) recommends a maximum contaminant level in potable water supplies of 10 ppb.

Lewatit® FO 36 is designed to reduce the arsenic contamination in potable water supplies, and meet stringent requirements of regional legislation at the same time.

Table 1: Limits of arsenic concentration in potable water

Country	Marginal Value (ppb)	Source
Germany	10	Trinkwasserverordnung – TrinkwV 2001
EU	10	Council Directive 98/83/EC
USA	10	National Primary Drinking Water Regulations
China	50	Water Quality Standard for Drinking Water Sources CJ 3020-93
Chile	50	The Official Chilean Standard INN-Chile NCh 409/1
Bangladesh	50	Environmental Conservation Rules of 1997
India	50	The Environment (Protection) Rules 1986
WHO conductance	10	The WHO Guidelines for Drinking-Water Quality

Figure 1: Major areas of arsenic occurrence in the world[1]



[1]Source: Smedley, P.L.; Kinniburgh, D.G.: "A Review of the Source, Behaviour and Distribution of Arsenic in Natural Waters", Appl. Geochem., 2002, 17, 517–568

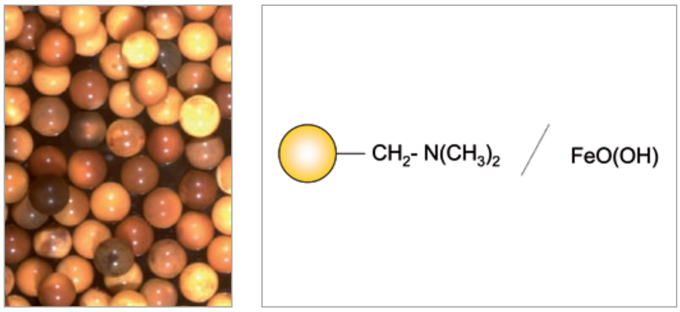
PRODUCT PROPERTIES

Lewatit® FO 36 is based on a polymeric, macroporous, weakly basic anion exchange resin. The ion exchange resin substrate is of uniform particle size (monodispersed), and relatively small (0.35 mm bead size) in comparison to standard sized ion exchange resin particles (0.60 mm). The rigid macro pores of the resin are filled with iron oxide particles that adsorb arsenate and arsenite complexes. The ion exchange resin serves as a rigid support for the iron oxide layer and provides dimensional stability to allow packed bed column operation. The combination of the ion exchange resin and iron oxide is termed a hybrid system.

The advantage of the uniform particle sized ion exchange resin is an equalized bed structure that provides a highly homogeneous flow through the bed resulting in "plug flow" adsorption. Fine beads that could cause plugging of filter collection nozzles are not present in the resin bed. The small bead size of the material results in a high specific surface area that leads to fast adsorption kinetics.

The "hybrid" nature of Lewatit® FO 36 is unique. It is the result of a special process developed by LANXESS, that provides a nano-scale, finely distributed and highly reactive iron oxide layer plated on the inside of the resin pores. The Lewatit® FO 36 has a content of approximately 15 % iron measured on dry weight base.

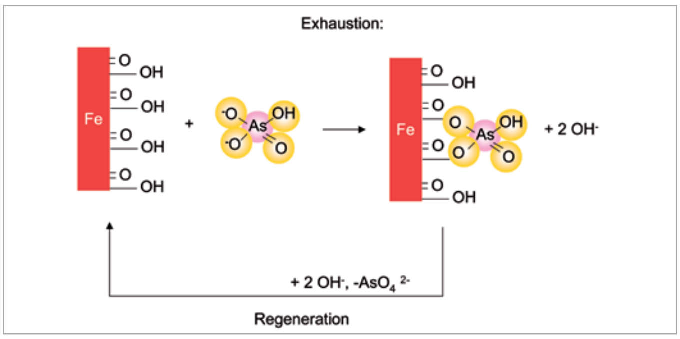
Figure 2: Chemical structure and appearance



FUNCTIONALITY

The layer of iron oxide binds arsenic in a specific surface complex. It adsorbs arsenate (V-valent arsenic) as well as arsenite (III-valent arsenic). A simplified scheme of the adsorption is presented in Figure 3 [uptake of As(V)]. An equivalent reaction scheme can also be created for binding arsenite (As(III)) on the iron oxide surface.

Figure 3: Simplified reaction scheme of As(V) uptake[1]



[1]These items are provided as general information only. They are approximate values and are not considered part of the product specifications.

SELECTIVITY

In comparison to classical strongly basic anion exchange resins, Lewatit® FO 36 selectively adsorbs arsenic, i. e., other major ions such as chloride, sulphate or nitrate are not bound to the resin and therefore, do not significantly influence the uptake of arsenic on the adsorber. This helps the water composition to remain constant except that arsenic is removed. Another positive effect is that arsenic, once it is adsorbed, cannot be desorbed by these competing ions [1].

Therefore, the total capacity of Lewatit® FO 36 should be significantly higher compared to a conventional anion exchange resin [2].

Minor water constituents such as silicate, phosphate and antimonate can also be adsorbed by Lewatit® FO 36. If present in the water, a co-adsorption takes place and operating capacity related on arsenic may decrease [3], [1].

REGENERATION

As shown in Figure 3 the reaction of arsenic uptake can be reversed, meaning that arsenic can be removed from the exhausted adsorber material by regenerating it with an alkaline solution. After regeneration, the Lewatit® FO 36 may be used for another loading cycle.

OPERATING CAPACITY

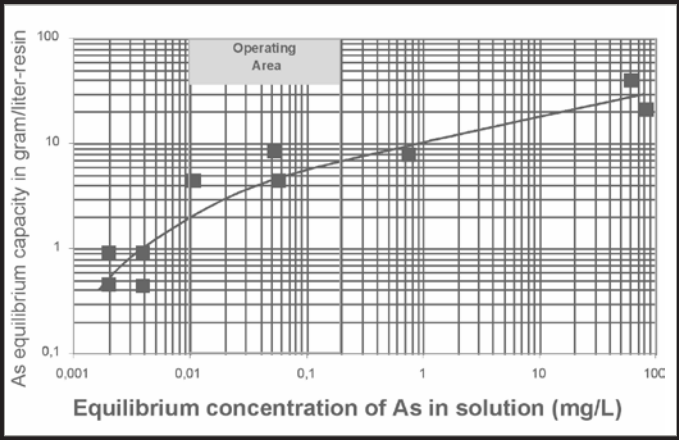
The arsenic uptake of Lewatit® FO 36 depends on the concentration of arsenic present in the solution and in equilibrium with the adsorbent resin. This is presented in Figure 4, which shows the adsorption isotherm for As(V) uptake from demineralized water on Lewatit® FO 36.

Under field conditions arsenic concentrations of 0.01 mg/l up to 0.1 mg/l are expected. It can be seen on Figure 4 that the equilibrium (static) uptake of arsenic in this range is 2.5 to 6 g of arsenic per liter of Lewatit® FO 36.

Figure 5 shows the breakthrough curve of Lewatit® FO 36 under field conditions. After approximately 18,000 bed volumes of feed have passed through the filter the outlet concentration reaches 10 ppb and subsequently a gradual breakthrough of arsenic begins. Operating capacity at the breakthrough point is 1.8 g of arsenic adsorbed per liter of resin.

This result was obtained with a relatively high specific velocity of 30 BV/h. It is possible that at a velocity of 10 to 20 BV/h the operating capacity could be up to 30 % higher. It is also possible that by using two filters in series operating capacities could increase by up to 50 % by loading first column to saturated capacity while the second filter serves as a polisher.

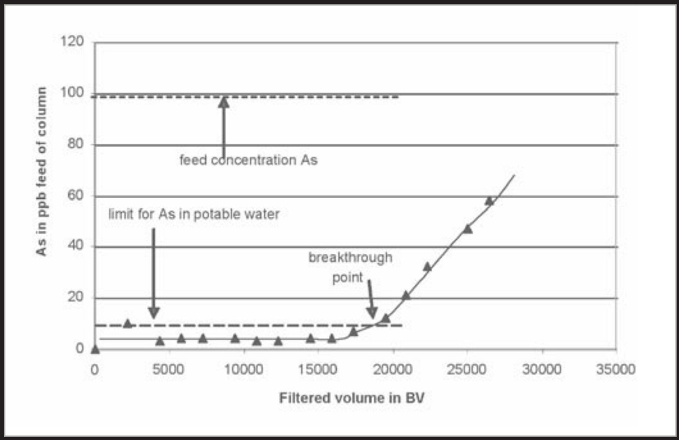
Figure 4: Adsorption isotherm of Lewatit® FO 36[1, 2]



[1] Adsorption of arsenic is at room temperature from neutral deionized water containing equilibrium rest concentrations of arsenic (V) in solution.

[2] As with any product, use of the products mentioned in this publication in a given application must be tested (including field testing, etc.) by the user in advance to determine suitability.

Figure 5: Lewatit® FO 36 breakthrough curve[1]

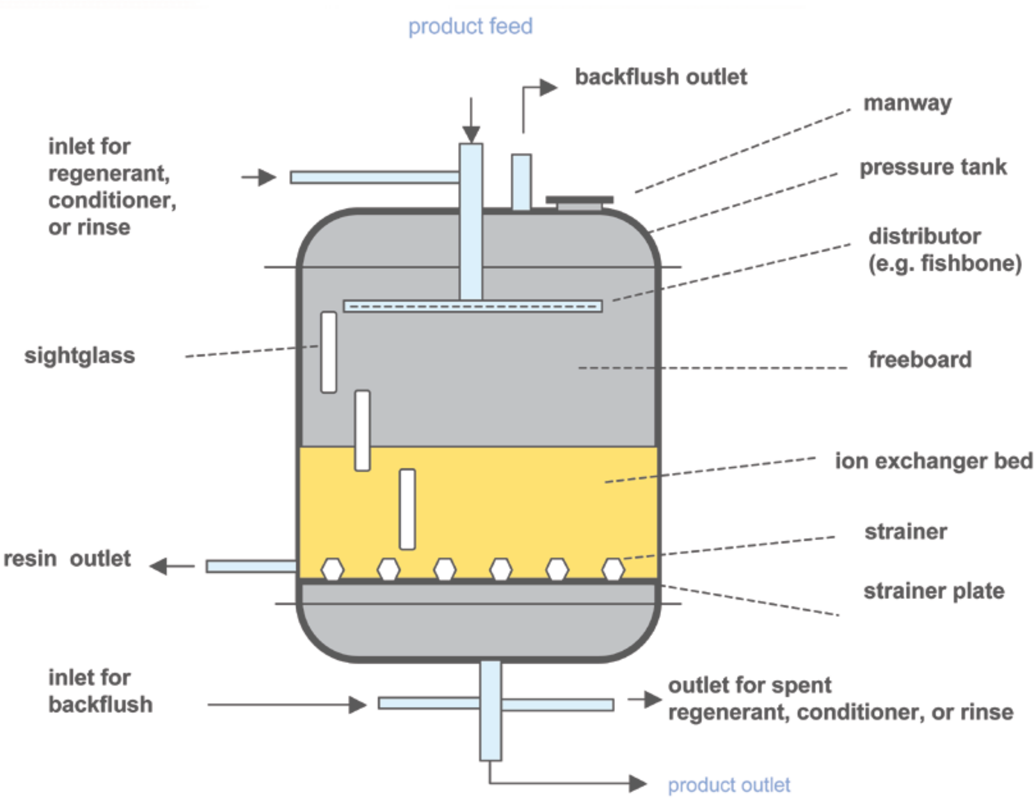


[1] Specific velocity: 30 BV/h, feed concentration 100 ppb arsenic V (as As) in neutral tap water 6 ppm Silica as SiO_2, 60 ppb Phosphorus, 100 ppb Fluoride, 160 ppm Bicarbonate, 50 ppm Chloride, 13 ppm Nitrate, and 43 ppm Sulfate.

FILTER DESIGN

Hydraulic filters with flow rates of 20 BV/h with bed depths of 1 m minimum yielded the optimal performance in our testing. The direction of flow should always be down flow. Because of the small particle size of the beads, pressure drop is higher than for conventional ion exchange systems. At 15 °C the specific pressure loss is approximately 2 kPa*h/m^2. For example, the pressure loss at a linear velocity of 20 m/h and a bed depth of 1.5 m will be 30 kPa, which equals 0.3 bar.

Figure 6: Main Constituents of IX-Filter Unit (Co-current process)



Upstream of the Lewatit® FO 36, any suspended particles should be removed by the use of a sand filter. Inlet concentrations of < 0.5 ppm of suspended solids are recommended. The feed solution should not be supersaturated with calcium carbonate. Otherwise, the column may get irreversibly plugged because of scaling. Degassing before filtration is also advantageous as bubbles of gas can accumulate in the resin bed and may negatively impact the contact between water and adsorber material.

The column should be designed with a free board of 100 % of the resin bed volume to allow backwash operations. The outlet tube for the backwash water should not be plugged by sieves or nozzles to allow suspended particles and broken beads to be washed out of the column.

If the resin bed gets plugged with suspended solid particles in the upper layers of the resin beds, the solids can be removed by carefully back flushing of the resin bed with rinse water. The linear upward flow of backwash water should be adjusted so that at least 40 % bed expansion may be achieved. The specific bed expansion factor of Lewatit® FO 36 at 20 °C is 10 % per m/h. Hence, the linear velocity for back flush should be adjusted at around 4 to 5 m/h.

It should be noted that back flushing of the column will destroy the established concentration profile of arsenic load within the adsorber bed. The so called "fine purification area", a highly regenerated area of the column will be destroyed causing an increase of arsenic leakage during further operation. Thus, if backwashing has to be applied the process must be run with a second column switched in lag position. The lag column will adsorb the leakage from the lead column.

The column bottom distributor plate should be equipped with strainers of 0.2 mm slit width in a density of 80 nozzles per m^2. A gravel layer with gravel stones of 0.4 mm should cover the nozzle plate so that the heads of the filter nozzles are 50 mm under the surface of the gravel layer.

START UP PROCEDURE

We recommend disinfecting the empty column and the connected pipe work prior to filling Lewatit® FO 36 into the vessel. After flooding the column with potable water the resin is loaded from the top. After the column is sealed, the back flush with potable water and 50 % bed expansion (see above) is carried out for half an hour to wash the resin bed. After the bed has settled down, the resin is rinsed in the down flow mode with at least 20 BV of water at a velocity of 5 BV/h.

REGENERATION PROCEDURE

For regeneration purposes 3 BV of an aqueous solution of 2 % NaOH and 3% NaCl is applied at a flow rate of 3 BV/h. Then, the resin is rinsed with 8~10 BV of water at 3~5 BV/h. The unified regenerant and the rinse water is acidified to pH 2. Then iron(III) sulfate is added followed by a neutralization to precipitate iron hydroxide as well as iron arsenate. The sludge is thickened, filtered and dewatered and can be disposed of according to the local regulations. In most cases discharge of the sludge on a landfill is allowed.

DISPOSAL

Alternatively to the regeneration, the resin can be used as one-way material. By doing so, handling of arsenical solutions can be avoided and the arsenic is left stably bonded on a solid material. Disposal has to be carried out according to the local regulations.

Within the EU, the exhausted material has to be disposed according to the EU regulations with the waste code 19 08 07 (saturated and exhausted ion exchange resins).

CERTIFICATIONS

Lewatit® FO 36 has passed full tests of effect on water quality of the British WRAS, “Water Regulations Advisory Scheme-Approved Material”, and is in compliance with the European Resolution ResAP(2004)3. Total Organic Carbon (TOC) release is according to the AFNOR test T 90-601.

An NSF/ANSI-testing is currently under study, and results are expected soon.

LANXESS staff collaborates with the EU committees in order to create norms for the application of ion exchange resins and to assure a registered and licensed application in the potable water treatment.

LITERATURE

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