ENGINEERING BULLETIN

Arsenic removal for business and residential applications using FerrIX™ A33E

FerrIX™ A33E is a hybrid ion exchange resin designed for selective removal of arsenic from water. This Engineering Bulletin includes information for removing arsenic in light commerical and residential applications using both point-of-use and whole home treatment systems with FerrIX A33E.

Purolite®

BUSINESS AND RESIDENTIAL ARSENIC REMOVAL USING FERRIX™ A33E

Inside this Engineering Bulletin you will find an overview of Purolite resins that are effective in the removal of arsenic in business and residential applications.
For more detailed information on any product or to find a product for an application not mentioned, please go to www.purolite.com or contact the Purolite office closest to you, listed on the back cover.

INTRODUCTION

Purolite is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. With global headquarters in the United States, Purolite is the only company that focuses 100% of its resources on the development and production of resin technology.

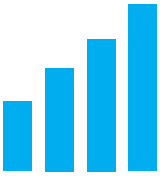
Responding to the needs of our customers, Purolite has built the largest technical sales force in the industry, the widest variety of products and five strategically located Research and Development groups. Our ISO 9001 certified manufacturing facilities in the U.S.A, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

PREMIER PRODUCTS

The quality and consistency of our products is fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.

RELIABLE SERVICE

We are technical experts and problem solvers. Reliable and knowledgeable, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales organization in the industry.



INNOVATIVE SOLUTIONS

Our continued investment in research & development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.

Purolite arsenic treatment solution

Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. It enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices.

Arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver, and prostate. Non-cancer effects can include thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis and blindness. (United States Environmental Protection Agency, 2015).

Health Canada has set the arsenic standard for drinking water at 0.010 parts per million (10 parts per billion) (0.010 mg/L) (Federal Provincial Territorial Committee on Drinking Water, 2006, p. 2) to protect consumers served by public water systems from the effects of long-term, chronic exposure to arsenic.

FerrIX™ A33E

FerrIX A33E is a proprietary hybrid ion exchange resin designed for selective removal of arsenic from water. This highly porous anion resin is infused with iron oxide to allow for fast and efficient adsorption of arsenic. The porous nature of the resin beads allows for maximum utilization of the infused iron. Iron oxide adsorption treatment for arsenic in groundwater is a common removal process that involves the chemical treatment of arsenic species. In the process, arsenic adsorbs onto the iron oxide to create larger particles that can be filtered out of the water stream. ("Ion oxide adsorption," 2015)

Water treatment systems incorporating FerrIX A33E resin are designed and operated using the same engineering guidelines as conventional ion exchange resins, and can be used in majority of existing lead-lag or parallel design configurations. This guide is meant to cover light commercial and residential applications for both point-of-use systems and whole home treatment systems.

The superior strength of ion exchange beads means fines will not be generated during resin loading or the service cycle. Pressure drop will remain low and backwash will be minimized, reducing water loss and avoiding the discharge of arsenic laden fines to the sewer.

- FerrIX A33E is certified to NSF/ANSI 61 Standard
- FerrIX A33E is ideal for municipal water treatment plants as well as point-of-entry (POE) and point-of-use (POU) systems
- FerrIX A33E is not hazardous according to OSHA 29 CFR 1910.120*

Table 1 – Physical and chemical characteristics

Polymer structure	Polystyrene cross-linked with divinylbenzene
Matrix structure	Macroprorous impregnated with iron oxide
Physical form and appearance	Brown spherical beads
Whole beads (min.)	95%
Bead size range	0.30 – 1.20 mm
Bulk density	790 – 982 g/L (49 – 51 lbs/ft^3)
Operating Capacity**	0.5 – 4 g As/L
Recommended contact time (minutes)***	2.5 – 5
Specific service flow rate (typical)	20 – 24 BV/h up to 32 BV/h (2.5 – 3 gpm/ft^3 up to 4 gpm/ft^3)
Minimum bed depth	1 m (36 in)
Operating temperature (max.)	176°F (80°C)
pH limits, operating	4.5 – 8.5

* Dispose of waste and residue in accordance with the requirement of local authorities .
** Will depend upon raw water composition and operating conditions.
*** Typical contact time is 3 minutes.

Arsenic is one of the hardest ions to remove from water. It has a high molecular weight and there are many factors that will impact its removal from water. One of the main factors is that phosphate ions are very similar to arsenic ions, and compete for exchange sites. If the feed water has high levels of phospate, the capacity for aresnic removal will be much lower. Another factor that will affect the ability to remove arsenic from water is the feed pH. It is best to maintain close to neutral pH (~7pH) for arsenic removal applications. At lower pH levels, arsenic can become insoluable and lose its ionic charge. The levels of natural arsenic in water will vary from area to area with the highest levels in areas with very deep wells.

Factors impacting arsenic removal capacity

The capacity of all granular iron media (GIM) used for arsenic removal are significantly impacted by the following factors:

- pH – increasing pH results in lower capacity
- Phosphate – competes vigorously with arsenic for exchange sites on media
- Silica – competes for exchange sites and can precipitate and/or bind with other foulants and block exchange sites
- Vanadium – competes vigorously with arsenic for exchange sites
- Other oxyanions (e.g. selenite, molybdate, antimonate, chromate) – will also have a negative effect on throughput capacity
- Specific flow rate – gpm/ft^3 of media or BV/h - higher specific flowrates results in earlier breakthrough and lower capacity
- Empty Bed Contact Time (EBCT) – lower EBCT results in earlier breakthrough and lower capacity

Essential data input

It is important to gather as much information as possible on the system so that “surprises” can be avoided. For example, aresenic III is typically non-ionic and will need to be oxidized prior to removal. Other anions and oxy-anions will compete with arsenic for removal by ion exchange resin so it is best to test for the following items prior to designing the treatment system:

- Arsenic III (ppb)
- Arsenic V (ppb)
- Vanadium (measured to ppb levels, eg. 10 ppb)
- Phosphate (measured in ppb levels, eg. 30 ppb)
- Silica (ppm)
- pH
- Other oxyanions (e.g. molybdate, selenite, antimonate, uranyl—total all in ppb)
- Peak flowrate - gpm or lpm
- Water usage/day - GPD or LPD
- Target maximum arsenic level in treated water

Other factors that affect fouling, precipitation and oxidation, or that impact MCL limits:

- Suspended solids
- Total hardness
- Iron / manganese
- Chlorine or other oxidants
- Nitrate
- Microbiological count (if suspected to be a problem)

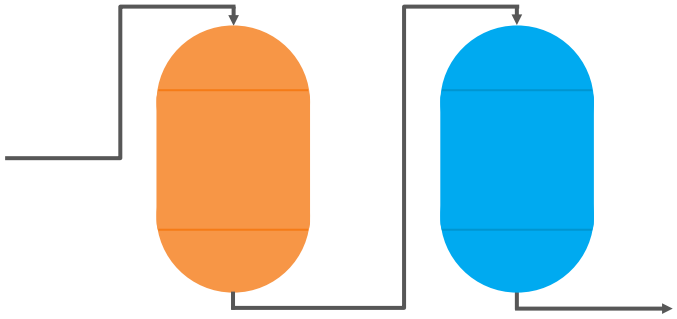
Special notes

The potential exists for nitrate dumping above the MCL due to residual anion capacity in the product. If nitrate in influent is above 5 ppm as N, contact your Purolite Technical Representative.

Equipment design parameters

We suggest using a lead/lag equipment arrangement to reduce the likelihood of arsenic leakage upon resin exhaustion. The lead vessel will do the majority of the arsenic removal and the lag vessel will act as a polisher removing any amounts of leakage for the lead vessel. On exhaustion of the lead vessel, replace the lead with the lag vessel and put fresh resin in the lag position:

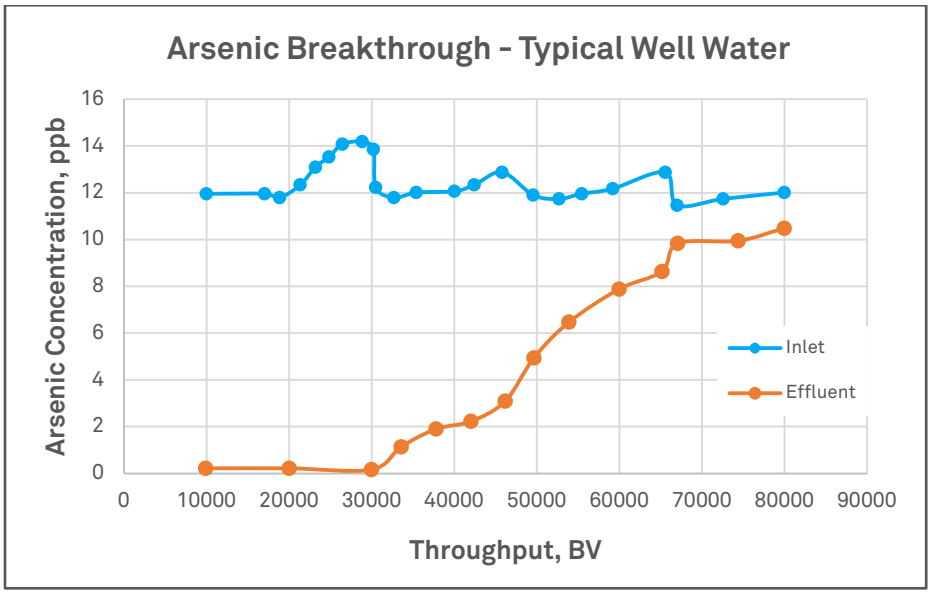
Lead/lag design



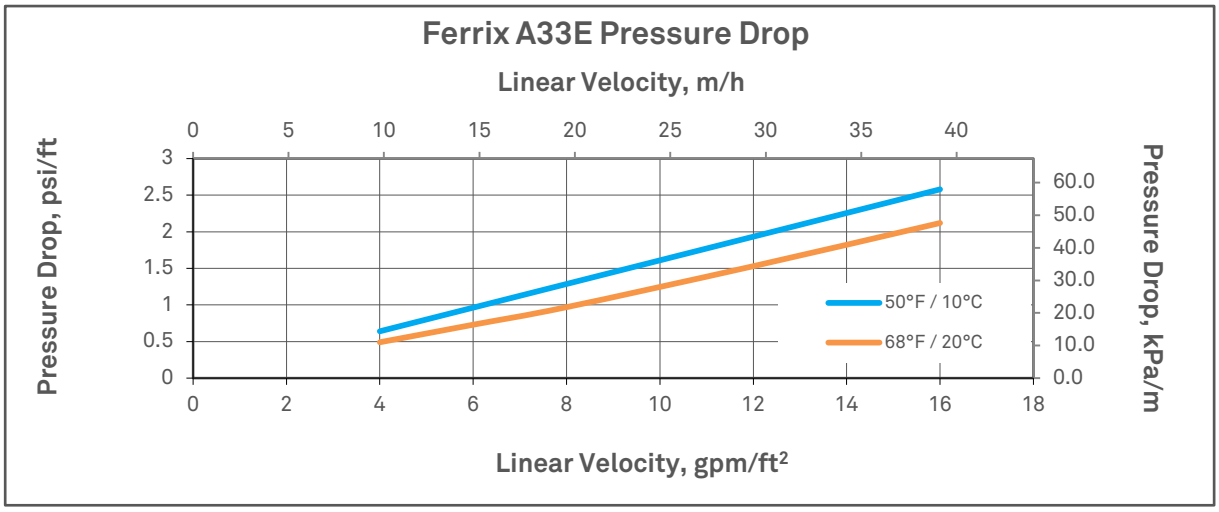
Other design parameters

- 2 – 5 minutes contact time
- < 6 gpm /ft^3 flow rate (< 48 BV/h)
- Bed depth > 30" (760 mm)
- Distributor design for 16 – 50 mesh media (300 – 1,200 microns)
- Sample ports at the inlet/inter-stage/outlet positions
- Discount capacity for higher flow rate
- Pre-filter for suspended solids to maintain < 1 NTU turbidity influent to the resin vessels
- Consult with Purolite on further design details

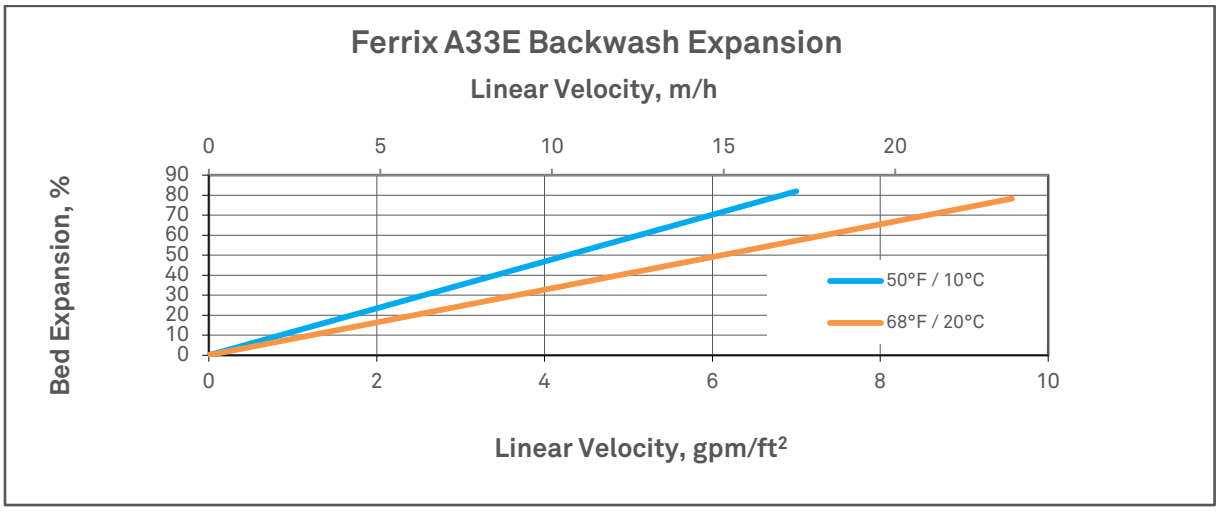
Typical breakthrough profile



Pressure drop curve, Ferrix A33E



Backwash expansion, Ferrix A33E



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United States Environmental Protection Agency. (2015, November 9). Chemical Contaminant Rules. Retrieved December 16, 2015, from http://www.epa.gov/dwreginfo/chemical-contaminant-rules

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Ion oxide adsorption. (2015). In *Wikipedia*. Retrieved December 16, 2015, from https://en.wikipedia.org/wiki/Iron_oxide_adsorption

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FerrIX™ Application Questionnaire

General Information (To be Completed by Sales Office)

Date: _____
Sales Office: _____
Sales Person: _____
Customer: _____

Customer Address: _____
_____
Customer email: _____
Customer phone: _____

Essential water inlet requirements	
Total hardness (ppm as $CaCO_3$)	
Alkalinity (ppm as $CaCO_3$)	
T.S.S. (ppm)	
T.D.S. (ppm)	
pH	
Nitrate (ppm)	
Arsenic V (ppb)*	
Arsenic III (ppb)*	
Vanadium (ppb)*	
Phosphate (ppb)*	
Silica (ppb)*	
Molybdate (ppb)	
Antimony (ppb)	
Selenium (ppb)	
Uranium (ppb)	

** Critical data input*

Application details	
Target arsenic leakage (ppb)	
Daily water requirements (USG)	
Flow rate (US gpm)	
Vessel diameter	
Number of vessels	
Resin bed depth	
Pre-oxidation	Yes ☐ No ☐
Chlorination	Yes ☐ No ☐
Pre-treatment	Yes ☐ No ☐

System limitations
Total arsenic > 2,000 ppb, vanadium > 100 ppb, phosphate > 1,000 ppb, silica > 90 ppm
pH > 9.0 or < 6.0
> 50 ppm of other oxyanions (Sb, Se, Mo, Ur)
> 5 ppm of nitrate

Contact your Purolite Representative for assistance if you exceed any of these parameters.

Design requirements
Minimum bed depth = 30" (36" is highly recommended.)
Two-vessel lead-lag design yields maximum capacity
Flow rate = 2.5 – 4 US gpm/ft^3 of resin
Maximum operating temperature = 80°C (176°F)

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