Engineering Bulletin

Arsenic Removal for Commercial and Residential Applications Using Purolite FerrIX™ A33E

Purolite 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 commercial and residential applications using both point-of-use and whole home treatment systems with Purolite FerrIX A33E.

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About Purolite

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

Responding to our customers' needs, Purolite has a wide variety of products and the industry's largest technical sales force. Globally, we have strategically located research and development centers and application laboratories. Our ISO 9001 certified manufacturing facilities in the USA, United Kingdom, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

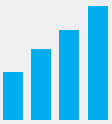
Purolite has been part of Ecolab since 2021. A trusted partner at nearly three million commercial customer locations, Ecolab (ECL) is the global leader in water, hygiene and infection prevention solutions and services. Ecolab delivers comprehensive solutions, data-driven insights and personalized service to advance food safety, maintain clean and safe environments, optimize water and energy use, and improve operational efficiencies and sustainability for customers in the food, healthcare, hospitality and industrial markets in more than 170 countries around the world.

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 well trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales team in the industry.



INNOVATIVE SOLUTIONS

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

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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). On January 22, 2001, the EPA set the arsenic standard for drinking water at 0.01 mg/l or 10 parts per billion (ppb) to protect consumers served by public water systems from the effects of long-term, chronic exposure to arsenic. Water systems had to meet the new standard by January 23, 2006 (United States Environmental Protection Agency, 2022).

Purolite FerrIX A33E

Purolite 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.

Water treatment systems incorporating Purolite 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. Although Purolite FerrIX A33E will remove both forms of arsenic that are most prevalent in water (As^{III} and As^{V}), the capacity is much higher when peroxidation is included in the treatment plan. As this is an anion-based resin all oxidizing chemicals must be removed prior to the resin.

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.

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

TABLE 1 Physical and Chemical Characteristics

Characteristics	Description
Polymer Structure	Polystyrene crosslinked with divinylbenzene
Appearance	Brown spherical beads
SBC	0.5–4 %
Particle Size Range	300–1200 µm
< 300 µm (max.)	1 %
Uniformity Coefficient (max.)	1.7
Shipping Weight (approx.)	720–760 g/L (45.0–47.5 lb/ft³)
Temperature Limit	80 °C (176.0 °F)
pH limits, Operating	4.5–8.5

* Dispose of waste and residue in accordance with the requirement of local authorities.

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 (~ 7 pH) for arsenic removal applications. At much lower pH levels, arsenic can become insoluble 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 lower arsenic removal capacity
- Specific flow rate — gpm/ft³ 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, other anions and oxyanions 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, e.g., 10 ppb)
- Phosphate (measured in ppb levels, e.g., 30 ppb)
- Silica (ppm)
- pH
- Other oxyanions (e.g., molybdate, selenite, antimonate, uranium—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

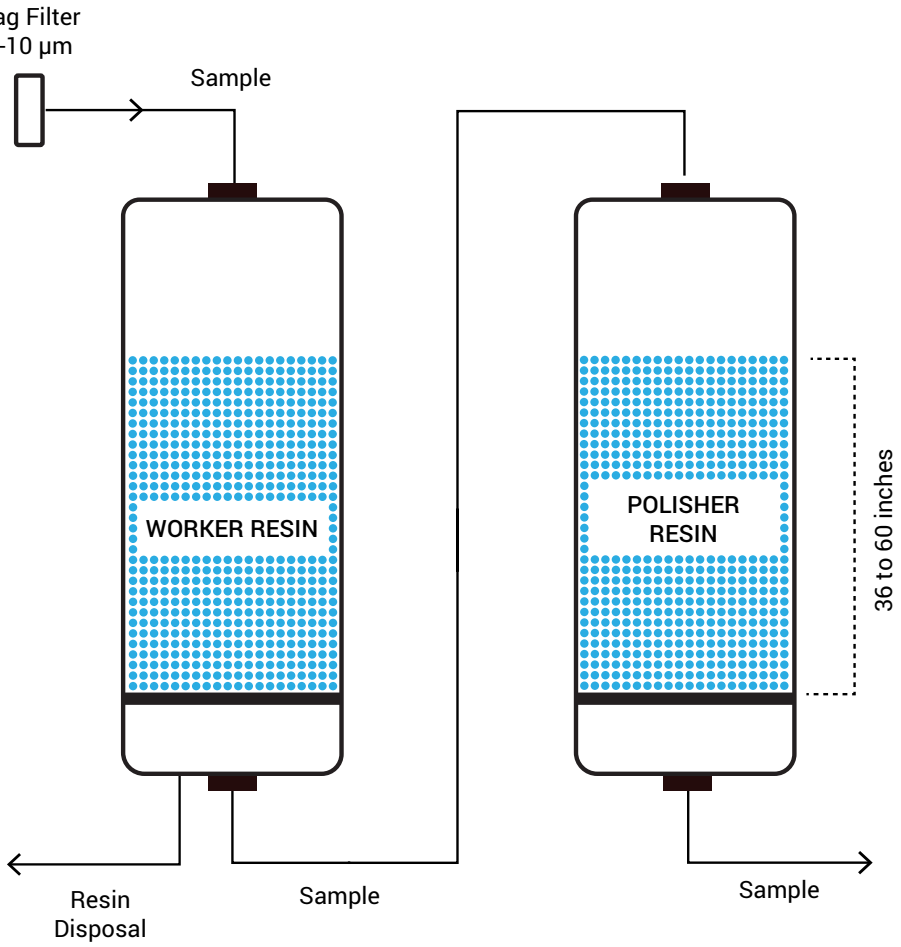
The potential exists for nitrate dumping above the MCL due to residual anion capacity in the product. If nitrate in influent is above 5 ppm as N, contact your Purolite Technical Representative.

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:

FIGURE 1

Lead/Lag Design



Other Design Parameters

- 2–5 minutes contact time
- < 4 gpm/ft^3 flow rate (< 30 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

FIGURE 2

Typical Breakthrough Profile

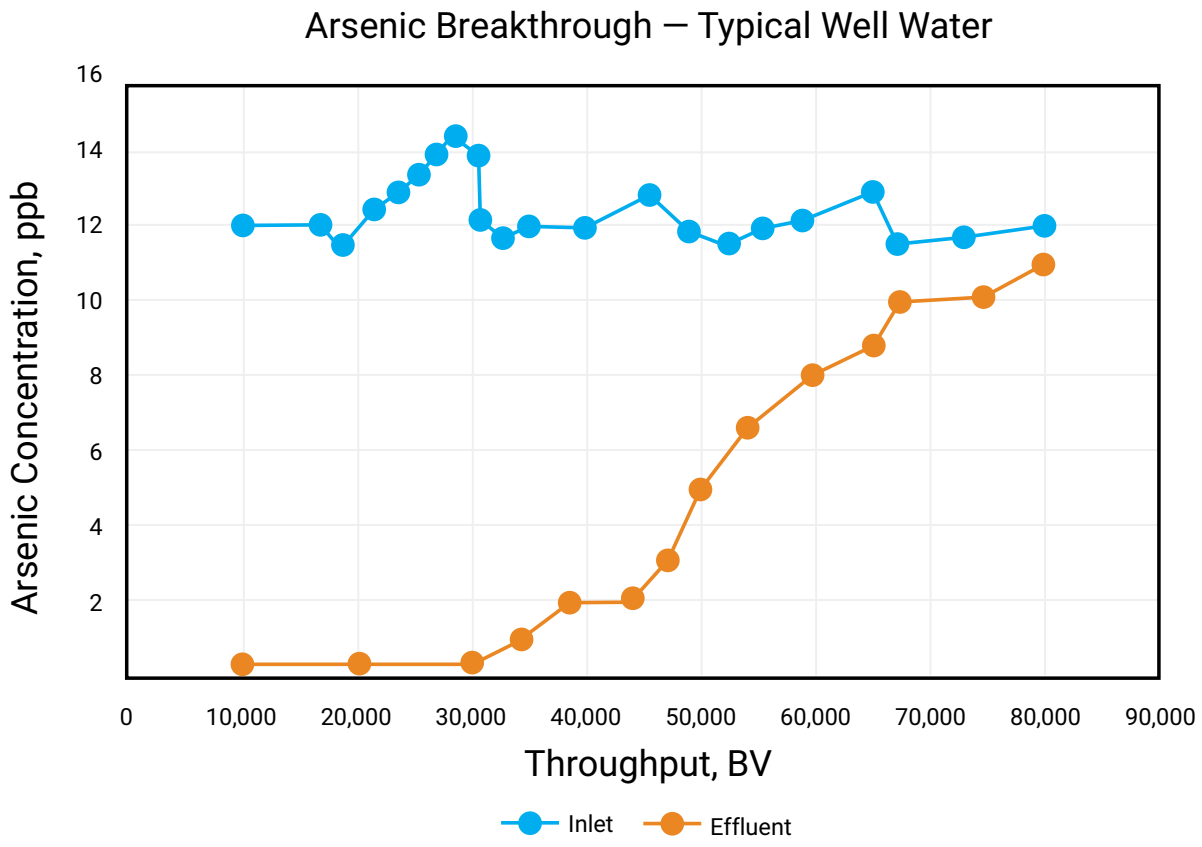


FIGURE 3

Pressure Drop, Purolite FerrIX A33E

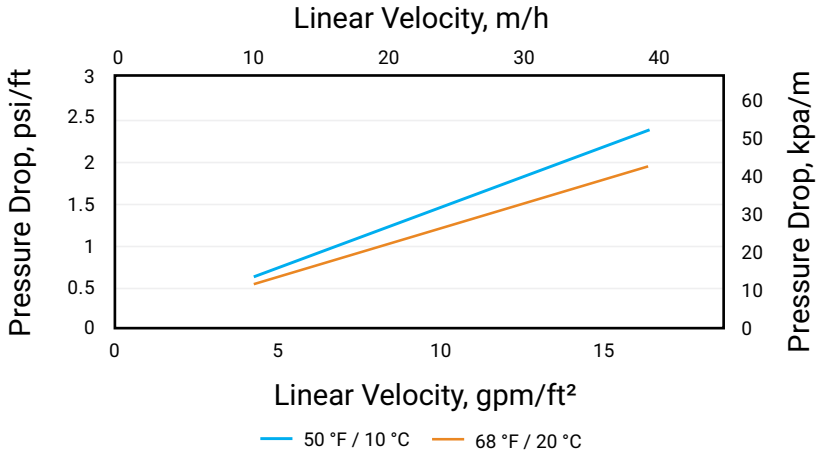
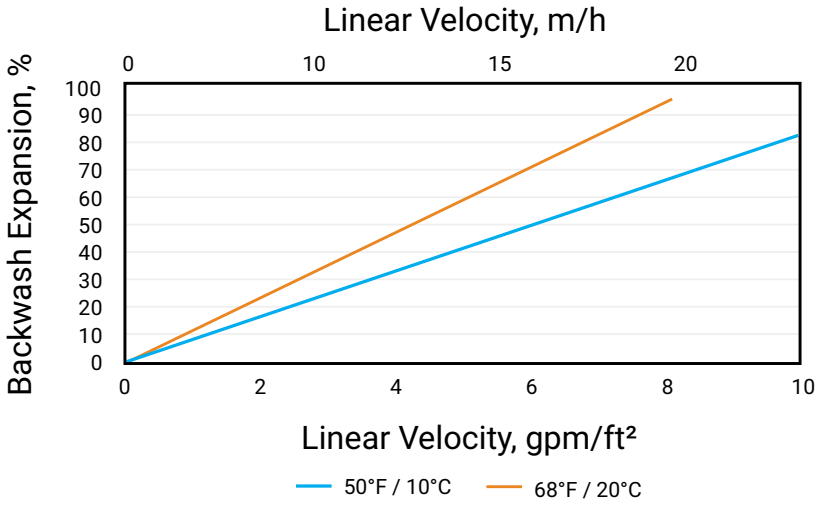


FIGURE 4

Backwash Expansion, Purolite FerrIX A33E



Note: Once the resin is put into service, backwashing is not permitted as this will lead to shortened bed life.

References

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United States Environmental Protection Agency. Retrieved January 18, 2022 from https://www.epa.gov/dwreginfo/drinking-water-arsenic-rule-history

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Purolite FerrIX A33E Application Questionnaire

General Information (To be completed by sales office)

Date:

Sales Office:

Sales Person:

Customer:

Customer Phone:

Customer Address:

Customer Email:

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 (m^3 or USG)	
Flow rate (m^3/h or US gpm)	
Vessel diameter	
Number of vessels	
Resin bed depth	
Pre-Oxidation/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 and pH > 6.0
< 50 ppm of other oxyanions (Sb, Se, Mo, Ur)
< 5 ppm of nitrate

Design Requirements

Minimum bed depth = 76 cm (30”). 91 cm (36”) is highly recommended
Two-vessel lead-lag design yields maximum capacity
Flow rate = 2.5 – 4 US gpm/ft^3 of resin
Flow rate = 12 to 30 BV/h (1.5 to 4 gpm/ft^3) of resin

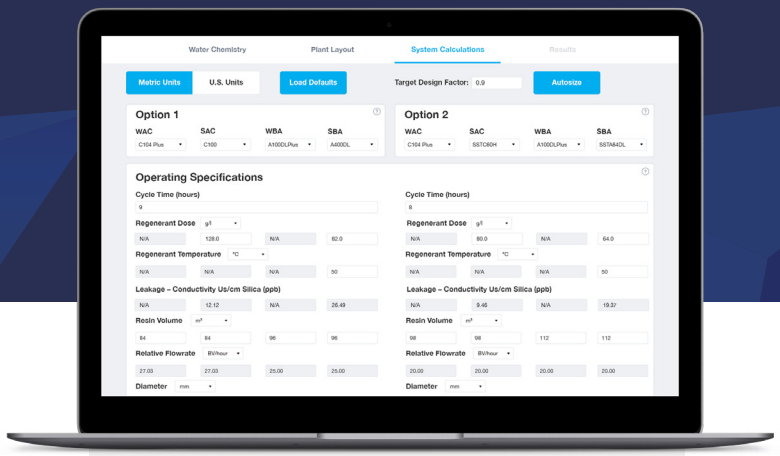
Contact your Purolite Representative for assistance if you exceed any of these parameters.

Notes

Customized Resin Simulation at Your Fingertips

PRSM™
Purolite Resin System Modeling

PRSM is a free program that models all aspects of plant design associated with ion exchange resin performance and operation.



Plan your next ion exchange resin project with better accuracy and less effort through Purolite's Resin System Modeling platform (PRSM™). This powerful web application for resin plant simulation contains seven specific system modules that instantly consider hundreds of variables. Whether you are designing a new plant or modeling an existing plant, Purolite's expert engineers are giving you the access you need to get the results you can trust.

Key Insight Every Step of the Way

Predict

Calculate the effect of your site's unique variables

Compare

Side-by-side product and plant configuration performance evaluation

Optimize

Add operation and product cost analysis to better understand the value of product options

PRSM includes modules for water softening, demineralization, WAC softening, brine purification, mixed beds and modules for removal of nitrate, arsenic and boron. Features include:

Technical Help – Reach out directly to Purolite engineers for advice

Cloud Backup – Easy and secure retrieval of projects

Reporting – Print/save a pdf of the entire design including all engineering details

ROI Payback Calculations – Contrast performance vs. standard resins

Efficiency Evaluation – Compare operating costs of existing ion exchange plant vs. new design

Schedules – Obtain detailed regenerant schedules for cation and anion resins

Page, Topic and Calculation Help – View detailed notes and suggestions for the optimal design

Register today and get started at **www.purolite.com/PRSM**

Notes

Notes

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Purolite, a leading manufacturer of quality ion exchange, catalyst, adsorbent and specialty high-performance resins, focuses 100% of its resources on the development and production of resin technology.

We're ready to solve your process challenges. For further information on Purolite products and services, visit www.purolite.com or contact your nearest Technical Sales Office.

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