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Energizing Chemistry

Selective Lewatit® ion exchange resins for efficient removal of PFAS contaminants from water

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Versatile specialists – comprehensive product portfolio provides advanced solutions

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Products and brands

Lewatit®
Lewatit® Scopeblue

- Ion exchange resins, adsorbers, and functional polymers for use in many industries and applications

Bayoxide®

- Granular iron oxide adsorbers for water treatment

LewaPlus®

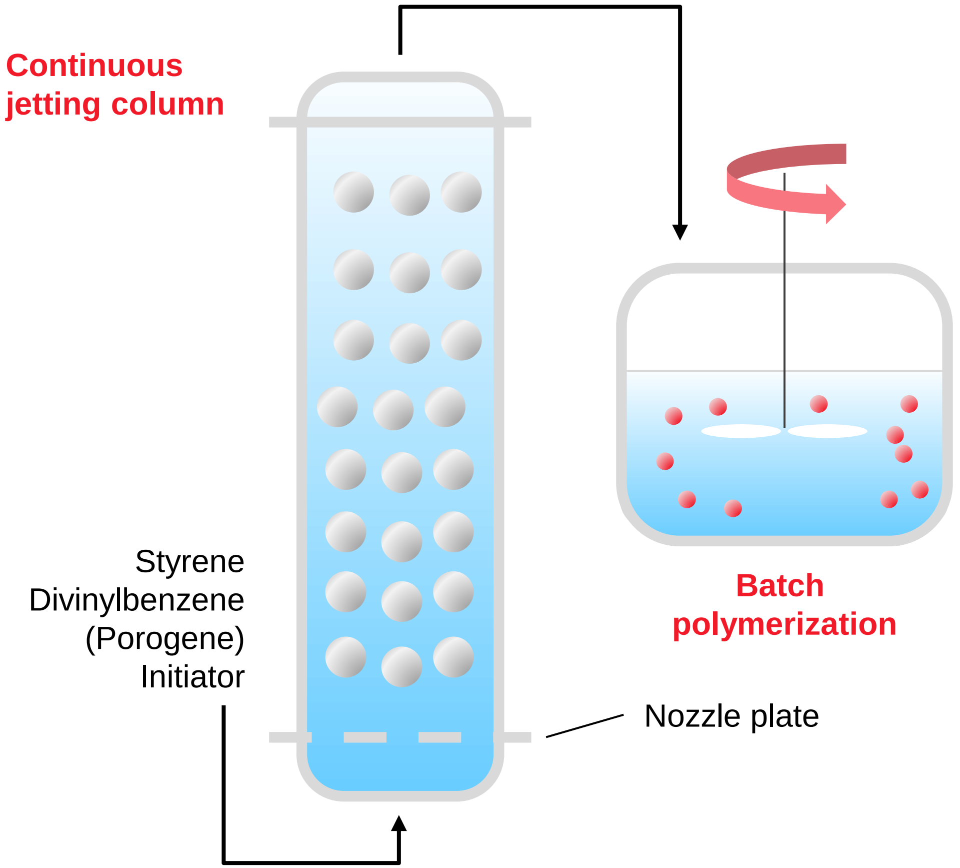
- Software for designing and optimizing ion exchange resin plants

Customer industries

Monodisperse droplet generation by jetting process

Stable scaffolds for demanding water purification applications!

Formation of monodisperse droplets



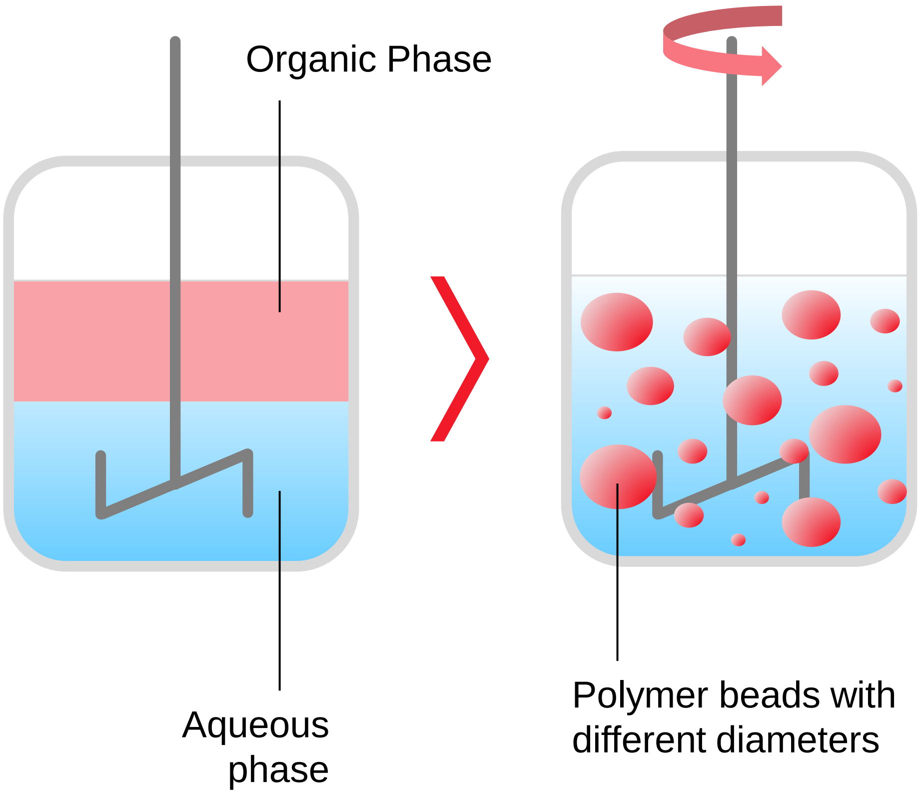
Description

- Continuous process
- Raw materials are fed through a nozzle plate at the bottom of the column
- The resulting monomer jet is chopped into droplets of the same size
- Particle size can be controlled by adjustment of the whole width of the nozzle plate
- The droplets formed at the bottom start to encapsulate as they proceed to the column head
- Polymerization of the monodisperse encapsulated droplets is completed afterwards

Suspension polymerization

A powerful tool to prepare stable Lewatit® ion exchange resins with superior properties

Batch type process



Description

- Batch type process
- Organic phase: monomer styrene, cross-linking agent divinylbenzene, radical initiator and porogen
- Aqueous phase: dispersing agent
- The resulting organic phase is dispersed in water to form small droplets.
- This particle size distribution can be controlled by the shear rate, i.e. stirrer speed

Bead size distribution: HD vs. MD

A flexible portfolio of solutions for critical separation challenges

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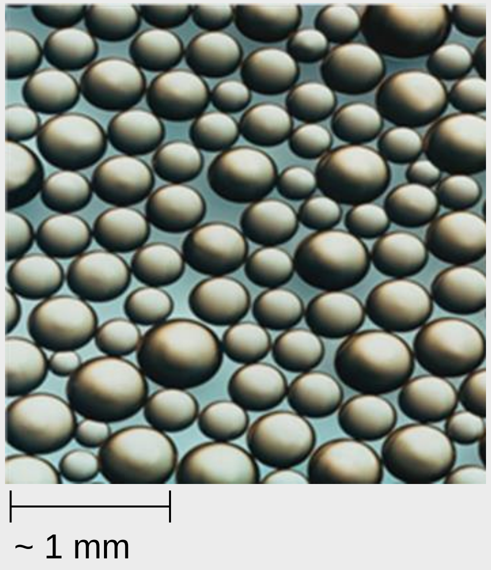
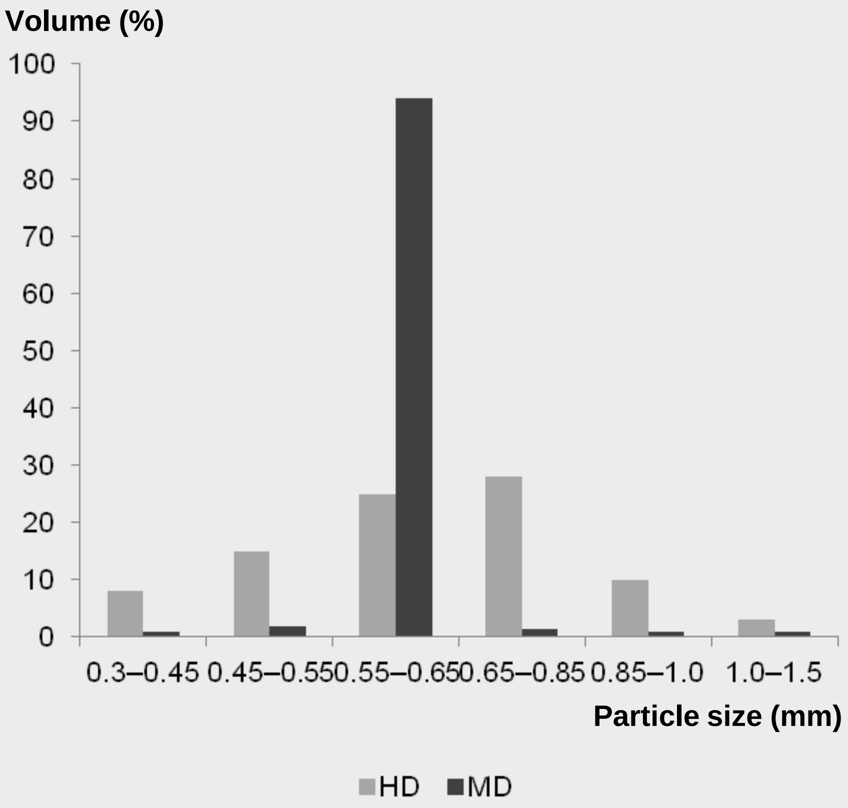
Heterodisperse (HD) beads

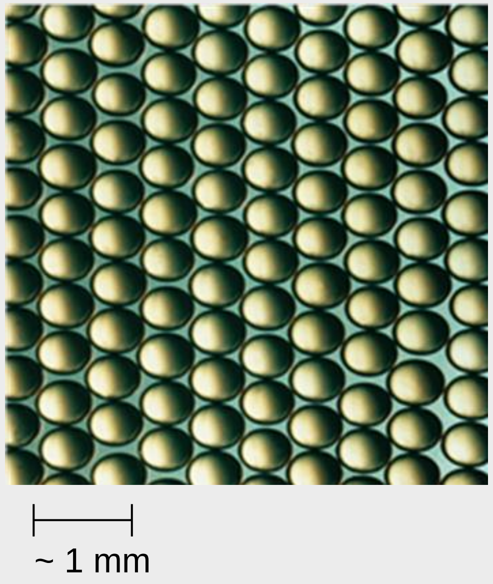


- Polymerization in conventional reactors under stirring

Particle size distribution



Monodisperse (MD) beads



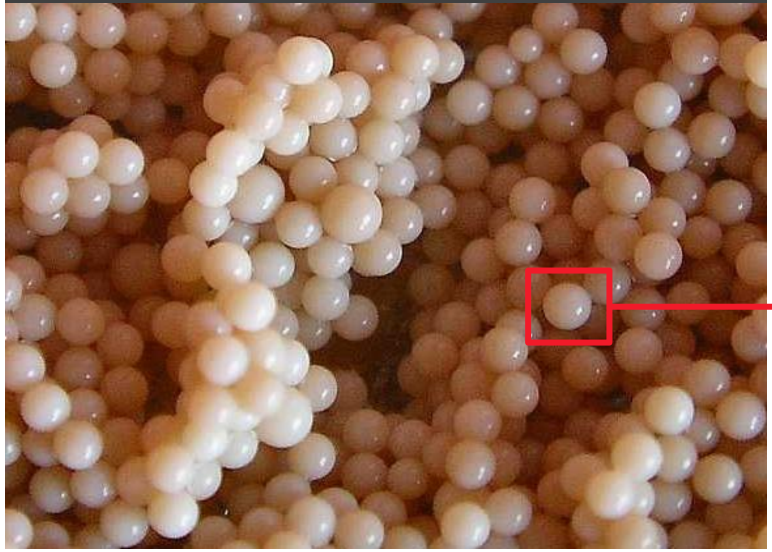
- Polymer manufactured in jetting columns
- Advantages in stability and operating capacity

The structure of macroporous resins

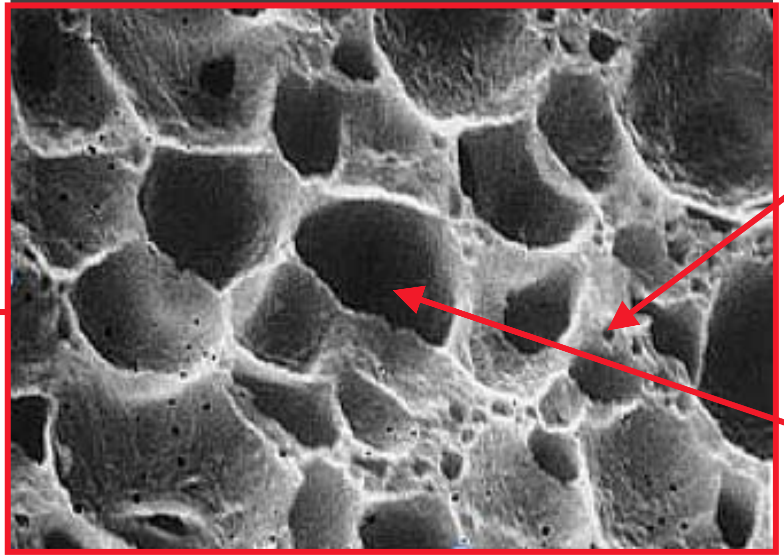
A flexible portfolio of solutions for critical separation challenges

Precise control over porosity for critical separation challenges!

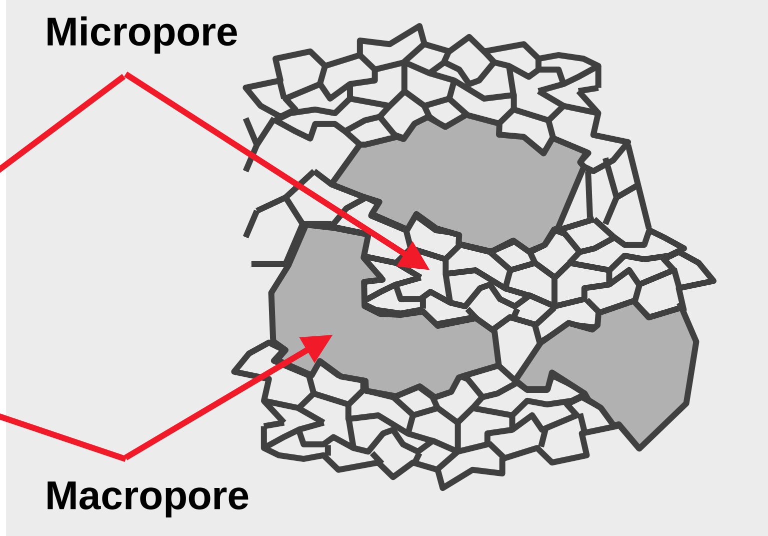
Microscopic image



SEM



Schematic structure



Functional groups

A strong portfolio of solutions for critical separation challenges

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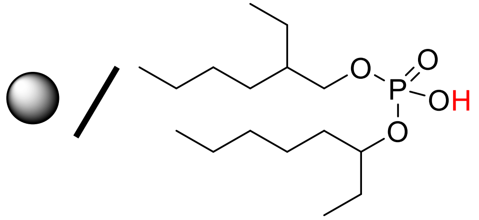
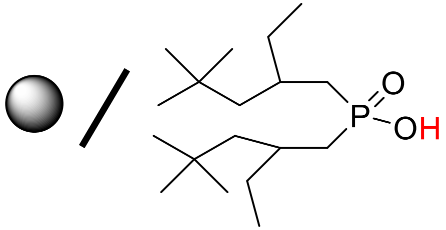
Solvent impregnated resins

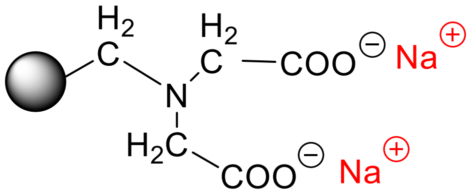


D2EHPA impregnated
Lewatit® VP OC 1026

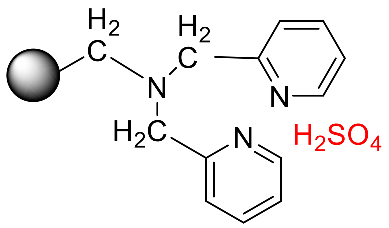


Cyanex 272 impregnated
Lewatit® TP 272

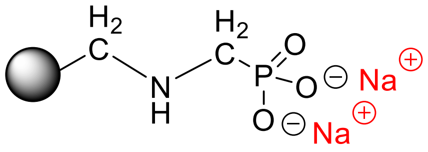
Selective chelating resins



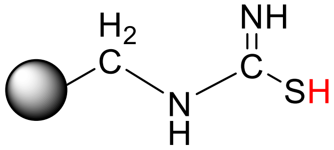
Iminodiacetic acid (IDA)
e.g. Lewatit® MonoPlus TP 208



Bispicolylamine (BiPicA)
e.g. Lewatit® MonoPlusTP 220

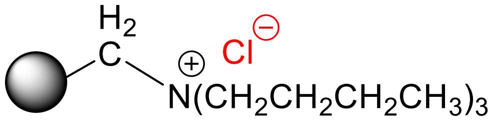


Aminomethylphosphonic acid (AMPA)
Lewatit® MonoPlus TP 260

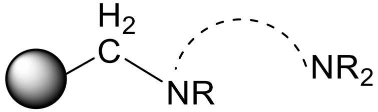


Thiourea
Lewatit® MonoPlus TP 214

Anion exchange resins



Tri-n-butylammonium
Lewatit® TP 106



Complex amine
Lewatit® A 365 (weak base)
Lewatit® TP 107 (strong base)

Resins and adsorbers for drinking water applications

A strong portfolio of solutions for critical separation challenges

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Portfolio of selected LANXESS products

Pollutant		Chelating resin	Strong base anion resin (SBA)					Ferric hydroxide adsorber
		Lewatit® MonoPlus TP 207	Lewatit® TP 107	Lewatit® TP 108 DW	Lewatit® TP 106	Lewatit® S 5128	Lewatit® DW 630	Bayoxide® E33 / E33 HC
Heavy metals	HM	■						
Chromium	CrO_4^{2-}		■					
Nitrate	NO_3^-				■			
Per- and polyfluoroalkyl substances	PFAS			■				
Perchlorate	ClO_4^-				■			
Natural organic matter	NOM					■		
Uranium	$UO_2(SO_4)_2^{2-}$						■	
Arsenic	AsO_4^{3-}							■

Country specific potable water approval certificates can be received as manufacture's declaration.

Key design properties of selective Lewatit® TP 108 DW

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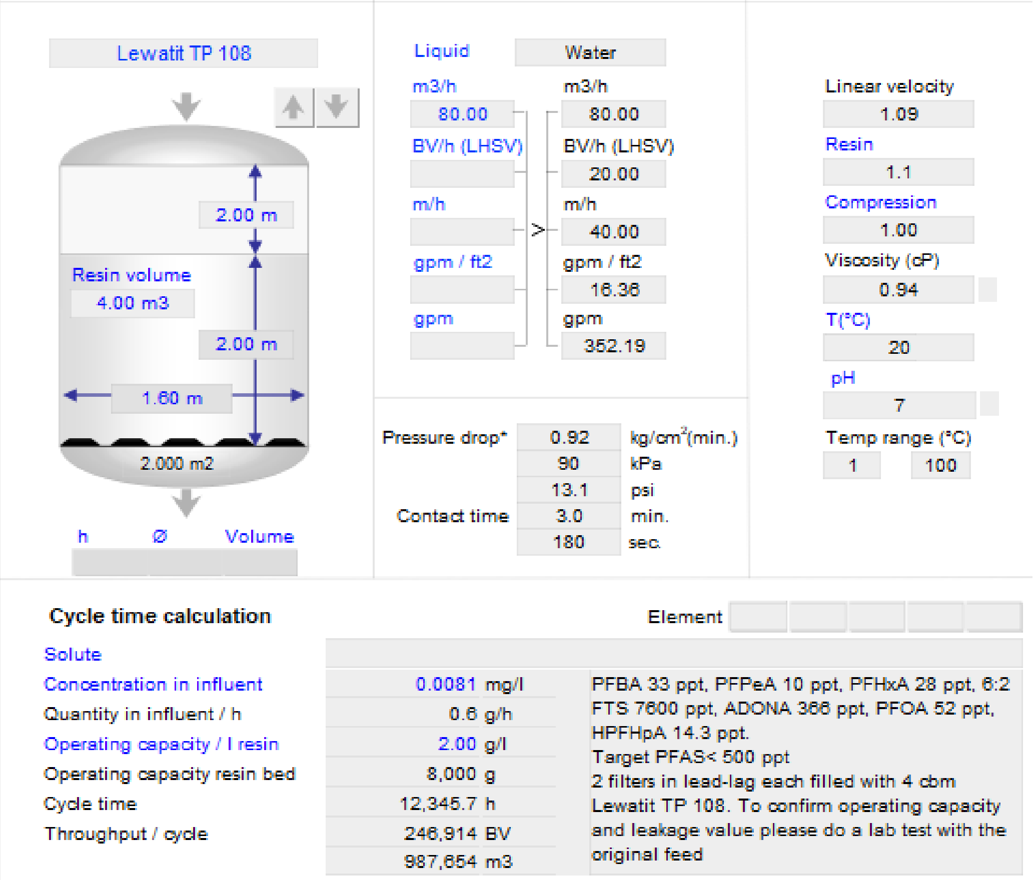
Precise control of resin parameters for critical separation challenges

- Functional group (Type of Amine)
- Polymer matrix (Styrenic or Acrylic)
- Morphology (Gel or Macroporous)
- Crosslinking
- Bead size
- Kinetics
- Resin swelling

Uniformity coefficient	1.7
Effective size	0.40-0.55
Fines	1
Total capacity (delivery form)	0.7

Delivery form	Cl^-
Functional group	quarternary ammonium
Matrix	styrenic
Structure	gel
Appearance	white, opaque



Chemical structures of most critical PFAS and their sources

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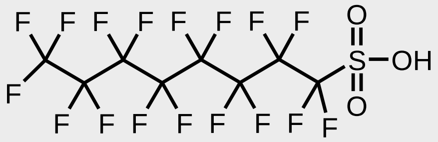
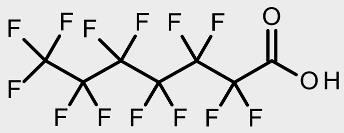
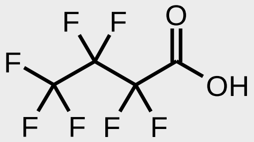
Per- and polyfluorinated compounds – toxic “forever chemicals”



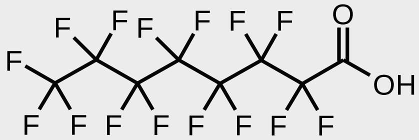
Perfluorooctanesulfonic acid (PFOS)
MW = 500 g/mol



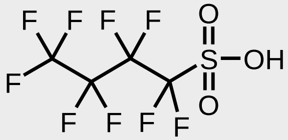
Perfluoroheptanoic acid (PFHpA)
MW = 364 g/mol



Perfluorobutanoic acid (PFBA)
MW = 214 g/mol



Perfluorooctanoic acid (PFOA)
MW = 414 g/mol



Perfluorobutanesulfonic acid (PFBS)
MW = 300 g/mol

A high-performance ion exchange resin required in order to remove mixture PFAS

Options for treatment of PFAS

Ion exchange most efficient technology especially for short chain PFAS!

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Reverse osmosis / nanofiltration

- Effectively removes even smaller chain PFAs
- Capex cost is high
- Operating cost and energy consumption is high
- Results in a relatively large waste stream

Granulated activated carbon

- Low-cost media difficult to change and expensive to reactivate
- Large footprint
- Low selectivity short chain PFAS results short cycles frequent exchanges

Ion exchange

- Fast kinetics, small vessels,
- Spent material is easy to be exchanged
- Very high selectivity, long cycles, low exchange rate

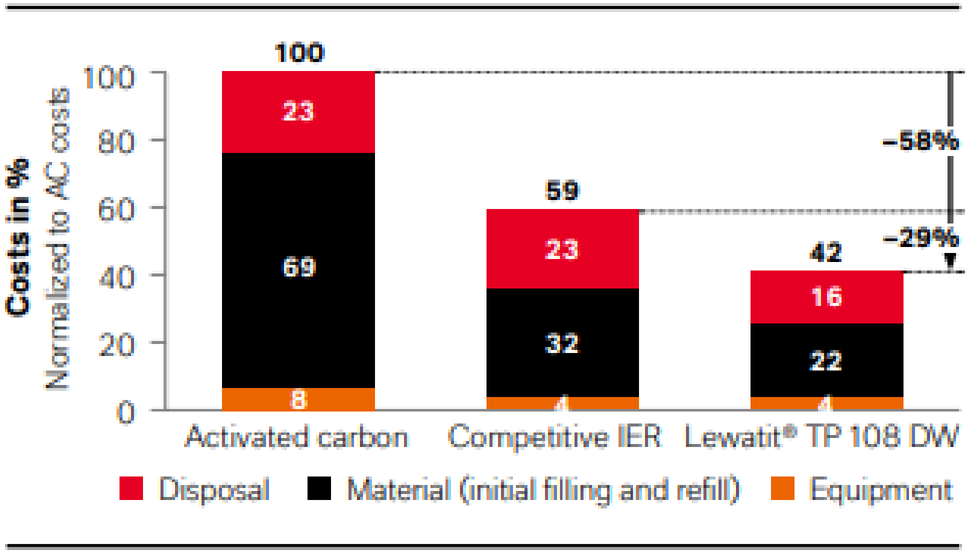

Figure 2: Cost calculation using Lewatit® TP 108 DW, a competitor ion exchange resin (IER), and activated carbon

Lewatit® range of resins offer a customized solution for the growing area of PFAS treatment

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Lewatit® TP 108 DW	▪ **Selective Lewatit® TP 108 DW** has the highest selectivity available for PFAS removal to provide the lowest residual concentration in treated water ▪ Especially effective against short-chains, e.g. PFBA types ▪ High total capacity min. 0.7 eq/L ▪ Resilient against organic fouling
Lewatit® K 6362	▪ **Lewatit® K 6362** has high capacity for long economical service runs ▪ Polisher for higher PFAS concentrations in wastewater ▪ Very high total capacity min. 1.3 eq/L
Lewatit® MP 62 WS	▪ **Lewatit® MP 62 WS** has medium selectivity for easier regeneration in service ▪ Suitable for highly contaminated waters such as point sources or aquifers ▪ Dissolved organic carbon (DOC) can interfere with PFAS adsorption, so pretreatment is important ▪ A high operating capacity of up to at least 3-4x compared with GAC systems

Interactions of PFAS with anion exchange resins

Strongest interaction between Lewatit® TP 108 DW and long chain PFAS

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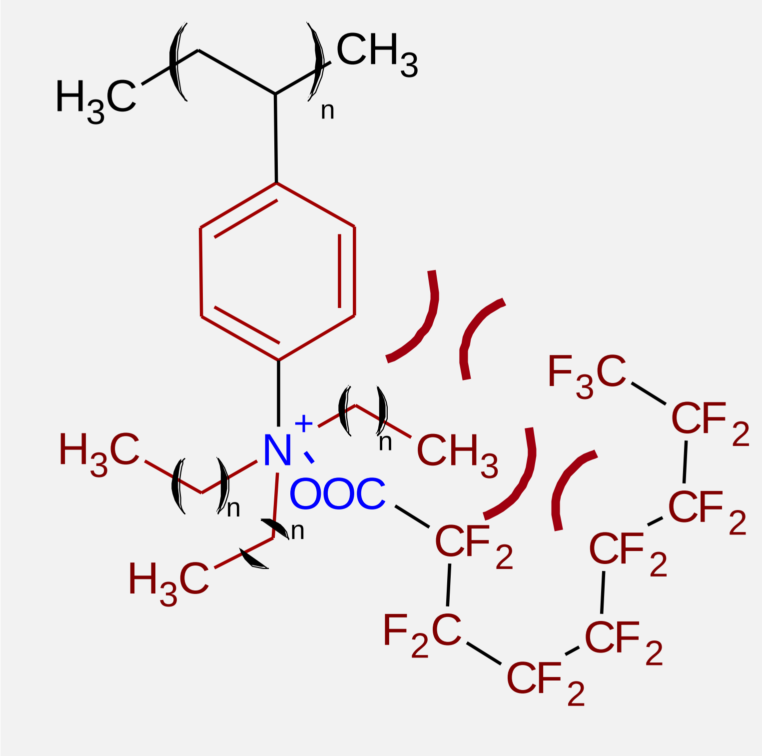
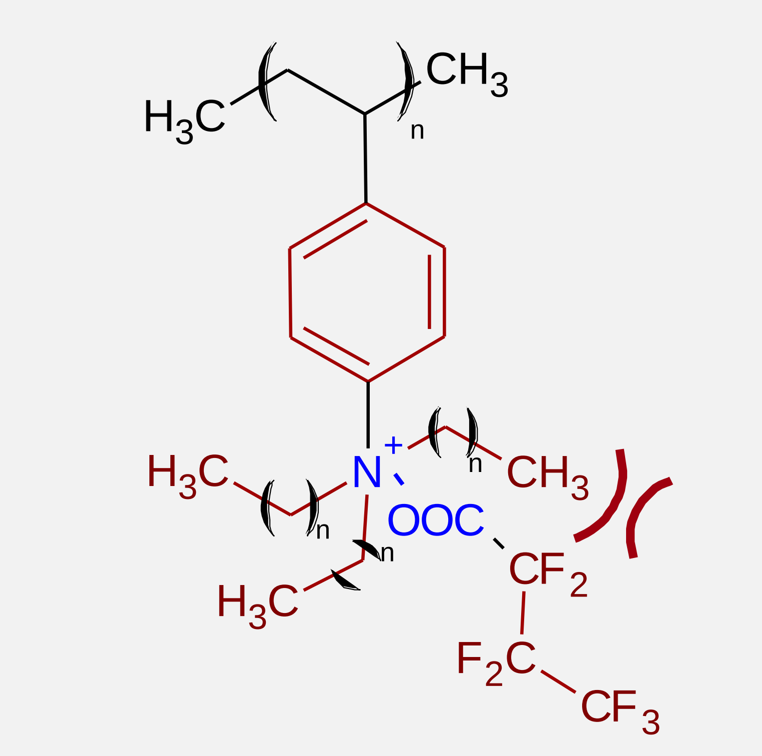
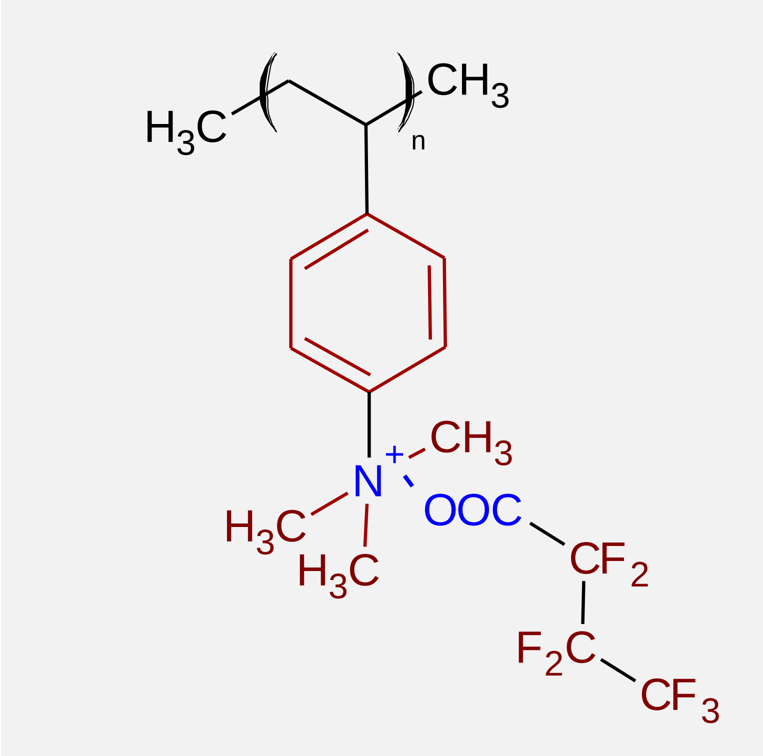
Strong interactions between TP 108 DW and PFNA	Medium interactions between TP 108 DW and PFBA	Weak interaction between K 6362 and PFBA
		

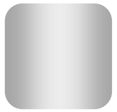
)(Hydrophobic interaction

n > 1

$N^{+-}COO$ Ionic interaction

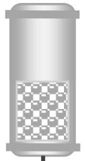
Required resins and filter arrangements

1) Waste water leachates from hot spots (PFAS influent: ppm-ppb)



Activated carbon
removal of natural
organic matter

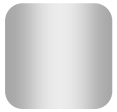
Macroporous regenerable:
Lewatit® MP 62 WS
Regenerable working filter



Strong base Lewatit® resin.
Polishing, especially short chain
PFAS

Purified water

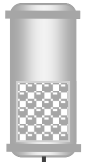
2) Ground water (PFAS influent: ppt)



Activated carbon
removal of natural
organic matter

RO unit

concentrate



Selective Lewatit® TP 108 DW
Polishing, longest cycle time lowest
leakage

Purified water

PFOA and PFOS removal from ground water

Lewatit® TP 108 DW offers longer lifetime than competitor resin and activated carbon

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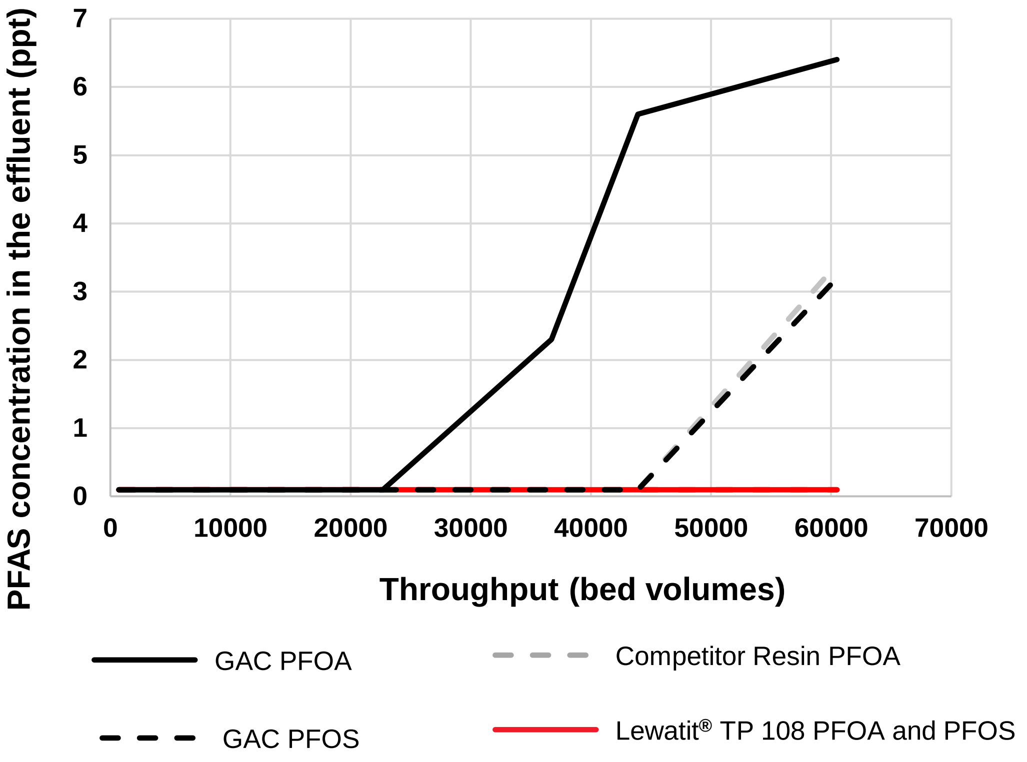
Operating Conditions	
Resin in Cl form	
PFOS	61 ppt
PFOA	44 ppt
Volume	75 L
pH	7
SV	15 BV/h
Temp	20°C
Breakthrough	> 1 ppt

PFOA and PFOS removal pilot in Italy



Lewatit® TP 108 DW offers the highest capacity for most PFAS species found in drinking water sources

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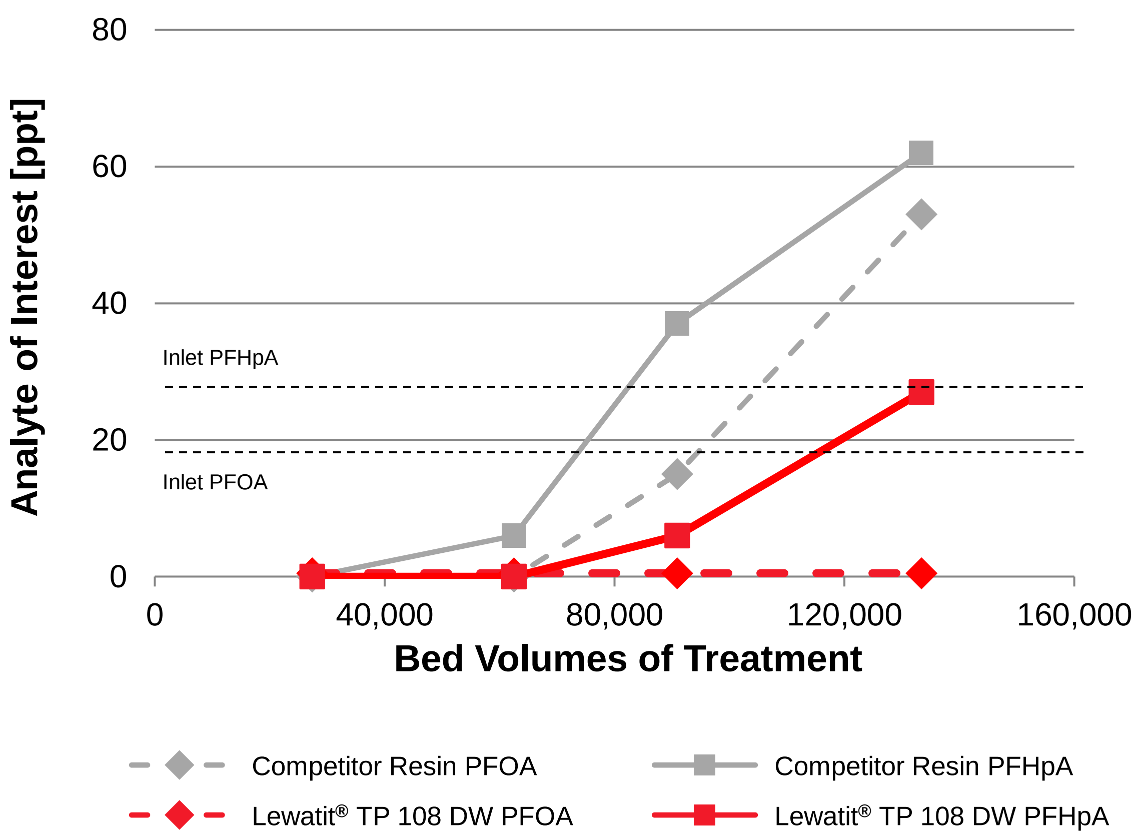
PFOA/PFHpA breakthrough curves generated USA



Potable grade resins

- Superior selectivity of one **Lewatit® TP 108 DW resin**:
  - Results in longer cycle times, 5-10 times the length of granular activated carbon
  - Means reduced leakage of lower Mw components
- Process changes such as backwash or flow rate changes don’t result in leakage
- Easy to change out media
- Low water requirement during start up

Lewatit® TP 108 DW offers the highest capacity for most PFAS species found in drinking water sources

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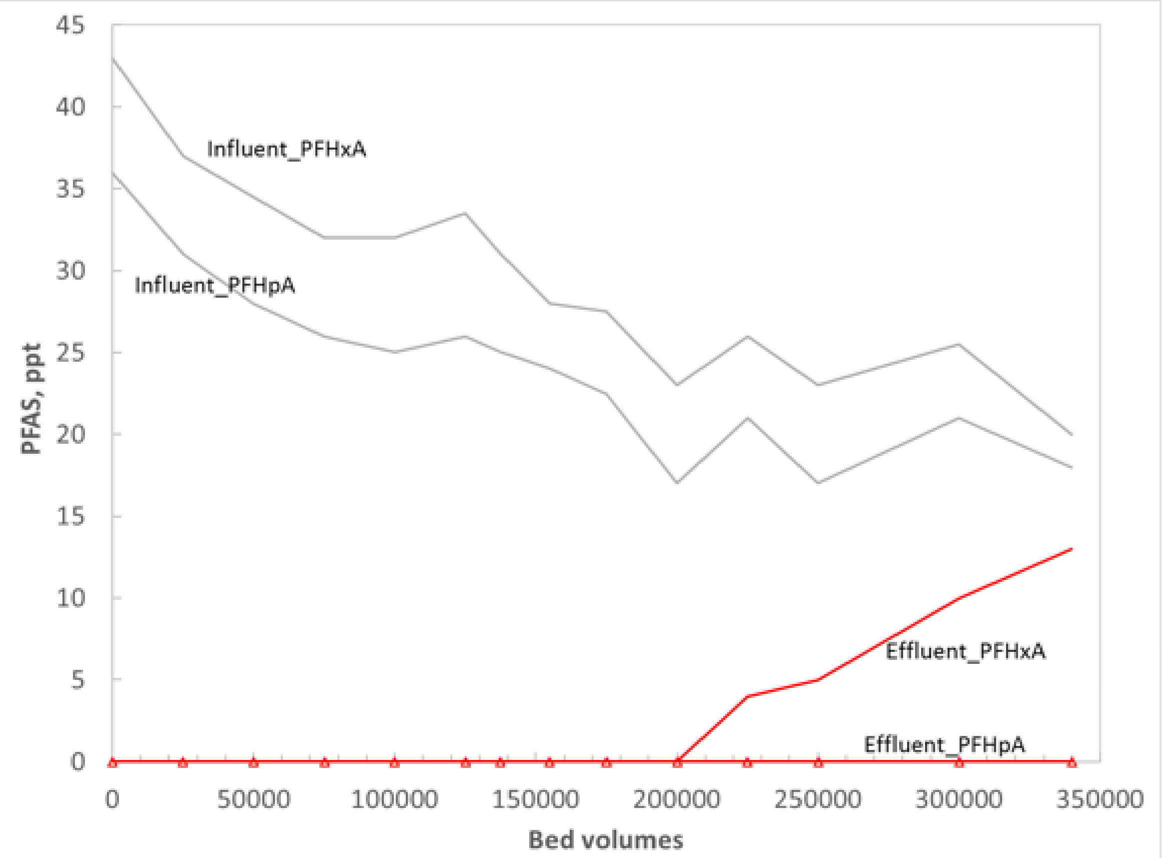
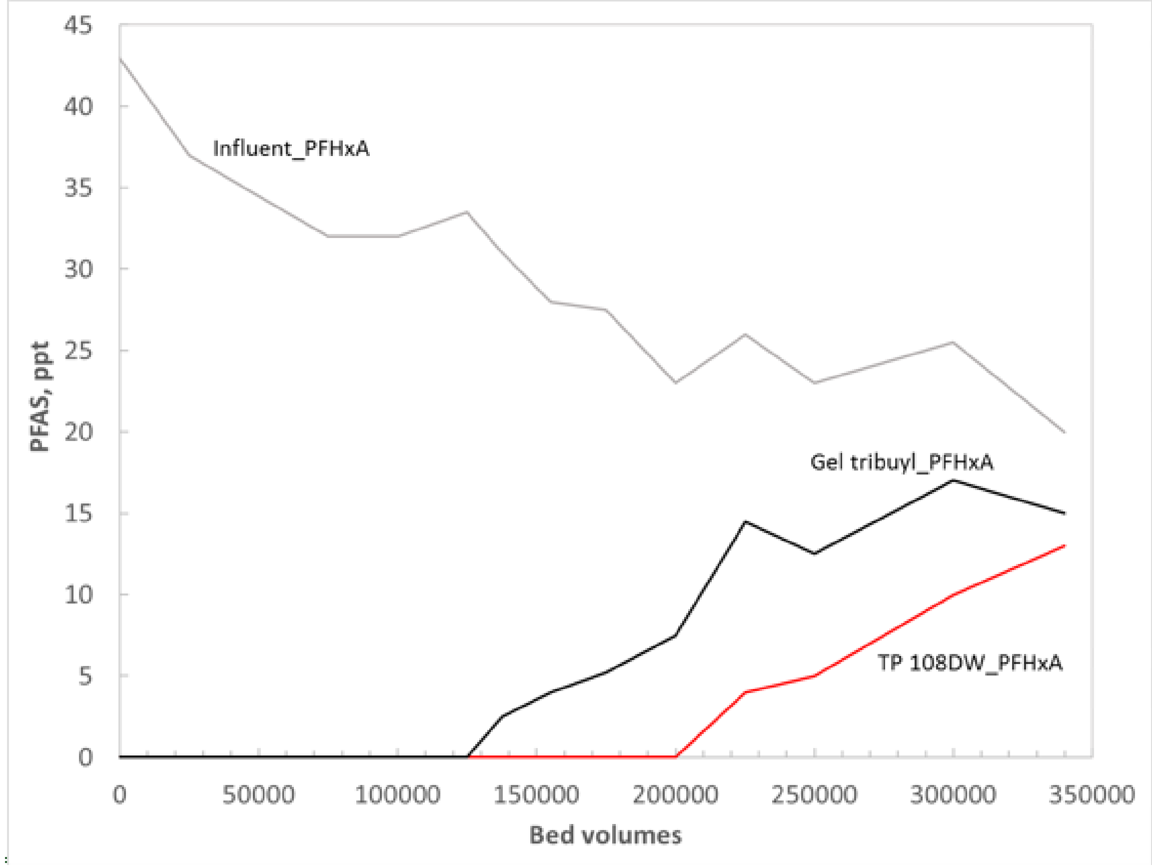
PFHxA and PFHpA breakthrough curves generated USA



PFHxA breakthrough curves generated USA



Case study at fire training site Australia

One of the most successful PFAS water treatment plants

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Containerized PFAS treatment plant

Characteristics

- Training using aqueous fire-fighting foam (AFFF) containing per- and poly-fluoroalkyl substances (PFAS)
- PFAS leached into groundwater.
- Discharge criteria for **long and short-chain PFAS** to comply with
- Processes: oxidation, pH adjustment, flocculation, solids separation, media filtration, ion exchange and adsorption

PFAS treatment in a fire-fighting facility

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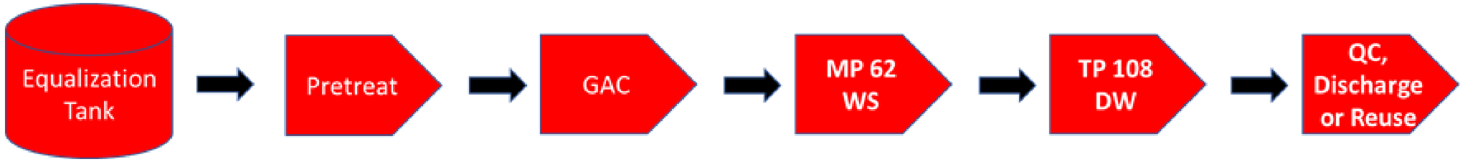

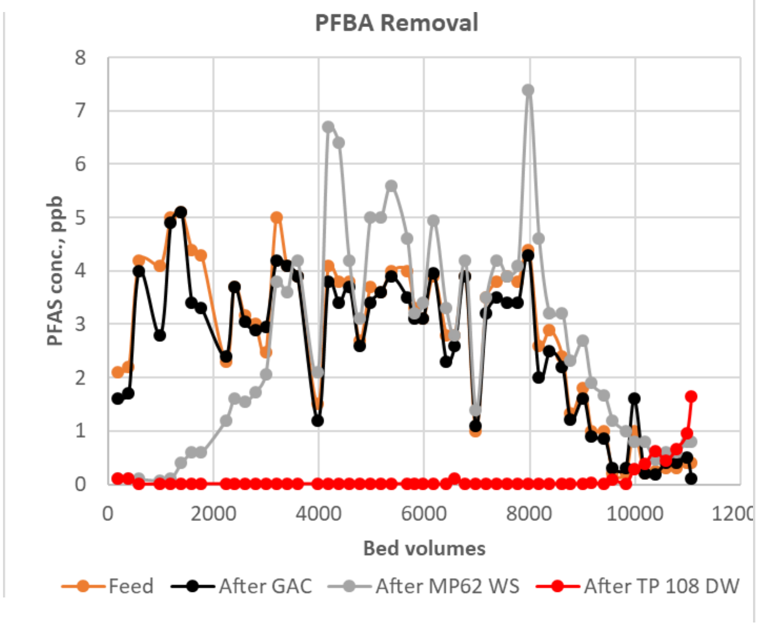

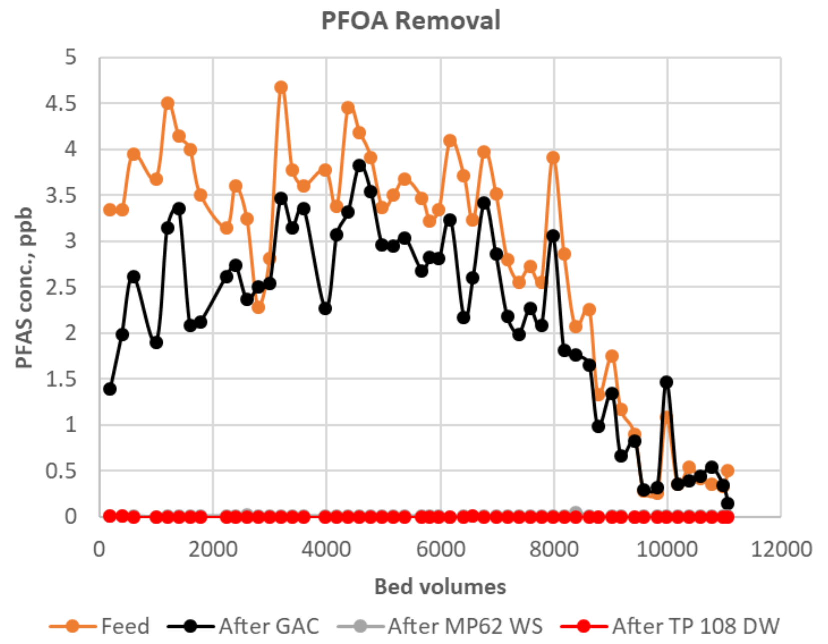

Lewatit® TP 108 DW reduced most PFAS compounds to non-detect!

PFAS treatment summary

- Influent: total PFAS up to 200 ppb
- **Effluent targets:**
  - PFOS and PFHxS combined total less than 0.07 ppb
  - PFOA less than 0.56 ppb
  - PFBA to non-detect level up to 10,000BVs
- 20 m^3/hour flow rate
- In operation for 12 months and treating nearly 14 million gallons of water
- Deemed one of the most successful PFAS water treatment plants in Australia

LANXESS has the right products and technical expertise for every application

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PFAS can be found in a wide range of concentrations and therefore, efficient purification solutions are required

Lewatit® offers unique resins for unsurpassed performance in even the most challenging scenarios

Lewatit® ion exchange resins have proven reliability on commercial scale

Longer run length between resin exchange results in a significant reduction in operating cost

Lewatit®

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