Lewatit® ion exchange resins for PFAS removal: Challenges and removal

Wilson Nova Ruiz, North America – Specialized Processing Manager
LANXESS Corporation, Business Unit Liquid Purification Technologies

March 7th, 2024

About the speaker and LANXESS LPT Team

LANXESS Energizing Chemistry

Speaker: Wilson Nova Ruiz

- **Business Segment Manager for Specialized Processing – Ion Exchange** North America – 2019 till now.
- 15 years with Material Protection Products – microbial control and industrial preservation, including water sterilization and clarification.
- Chemical Engineer, MsC in Economics and MsC in Finance.
- Operated, maintained and control for 5 years a small drinking water system for a bank building with 1000 users, in Bogota Colombia.
- LANXESS Corp main office Pittsburgh PA

Our Technical / Commercial Support

- **Dr. Dirk Steinhilber – Global Technical Marketing Manager – Hydrometallurgy and Contaminants Removal – Cologne Germany**
- **Dr. Zhendong Liu – Head of Technical Services and Business Development – Americas – NJ**
- **Dr. Kirtipal Barse – Drinking Water Segment Manager, North America – OH**
- **Ryan Denys – Regional Sales Manager, North America – MI**

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®

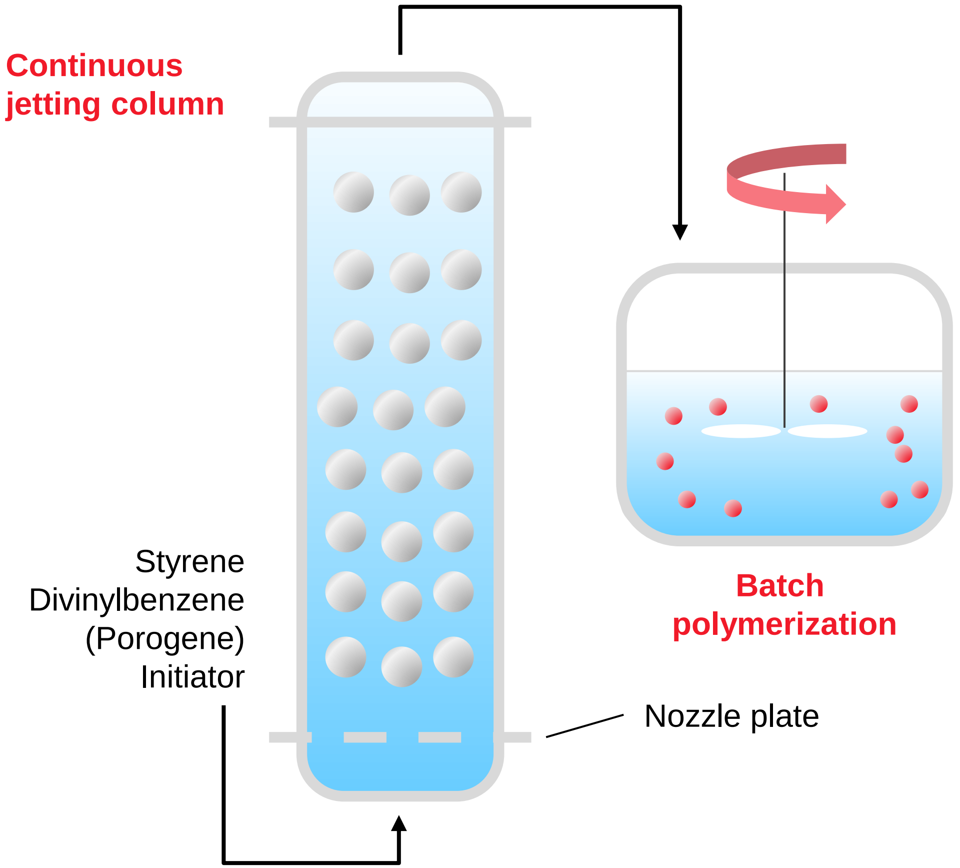
- Software for designing and optimizing ion exchange resin plants

Customer industries

Monodisperse droplet generation by jetting process

Stable scaffolds for demanding metals processing 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

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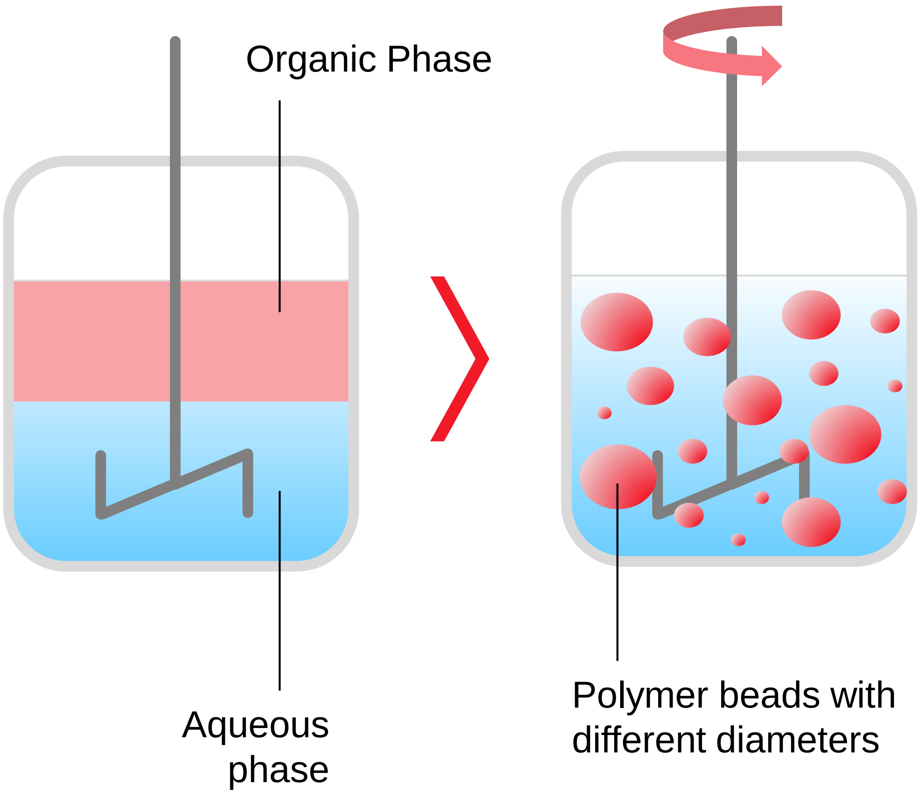
Batch type process



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

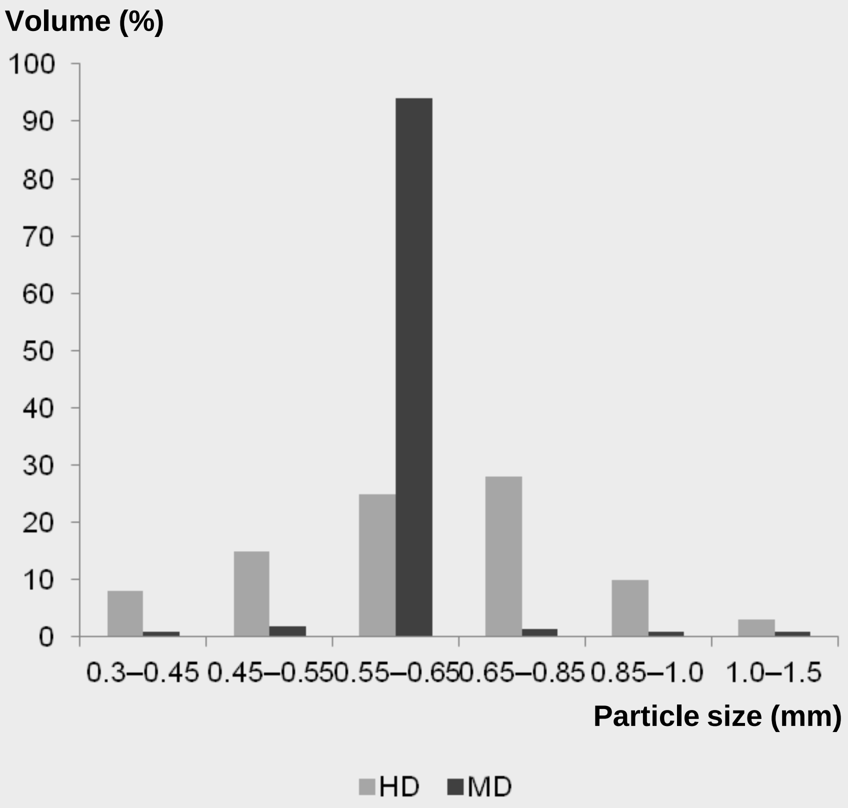
A flexible portfolio of solutions for critical separation challenges

Heterodisperse (HD) beads

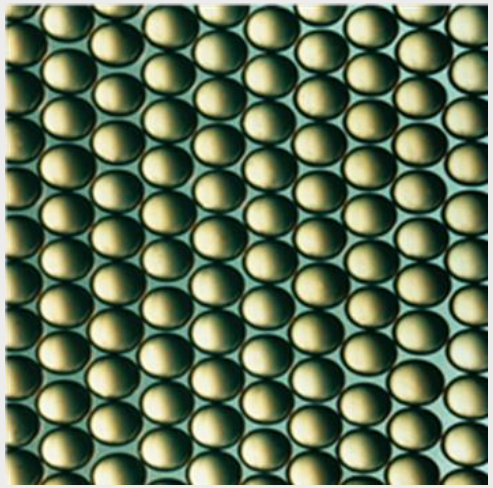
~ 1 mm

- Polymerization in conventional reactors under stirring

Particle size distribution



Monodisperse (MD) beads



~ 1 mm

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

The structure of macroporous resins

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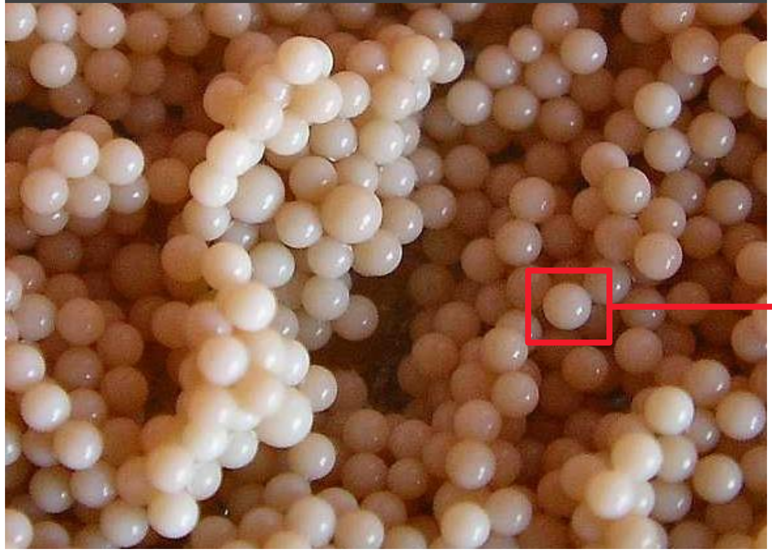
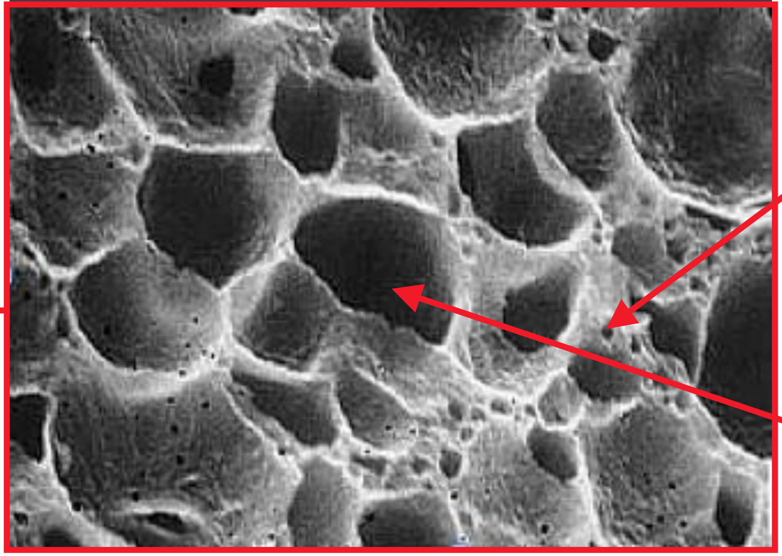
Small opaque beads are actually of a highly permeable sponge-like structure

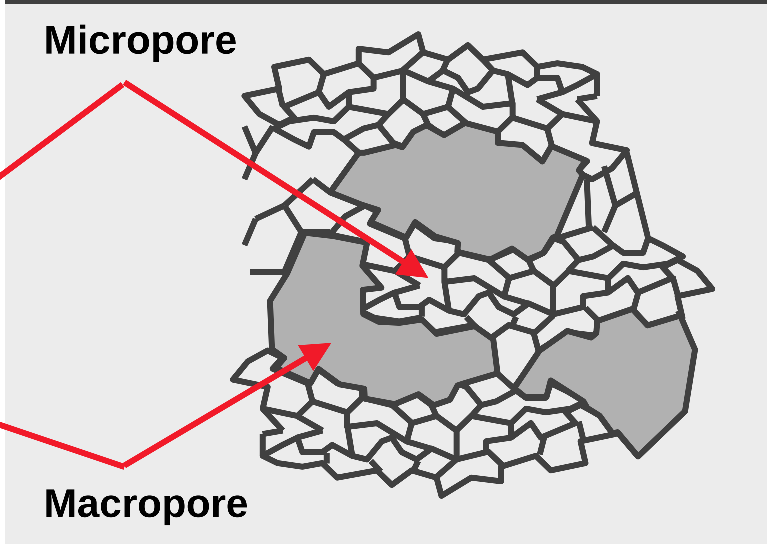
Microscopic image



SEM

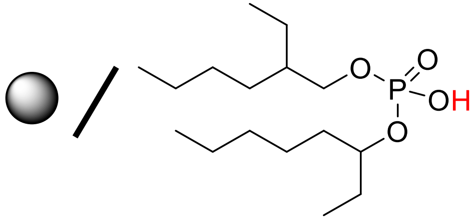
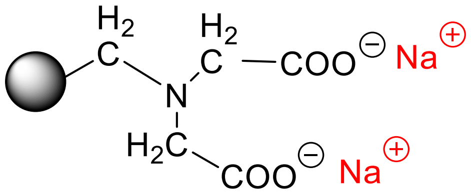
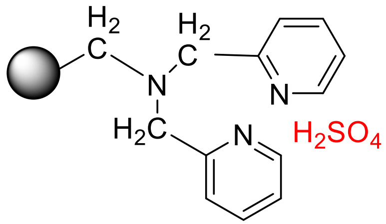
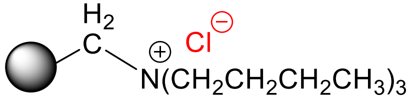
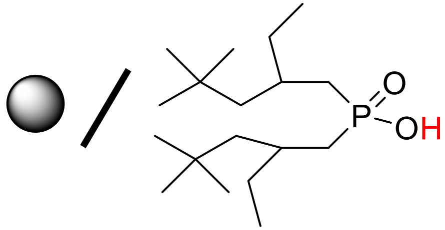
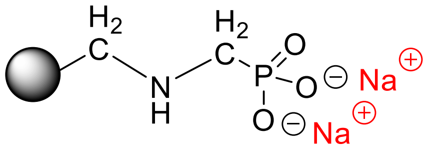
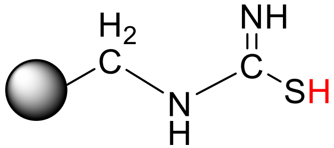
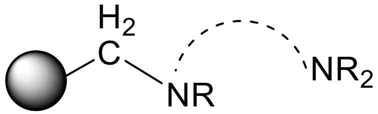


Schematic structure



Functional groups

A strong portfolio of solutions for critical separation challenges

Solvent impregnated resins	Selective chelating resins		Anion exchange resins
			
D2EHPA impregnated Lewatit® VP OC 1026	Iminodiacetic acid (IDA) e.g. Lewatit® MonoPlus TP 208	Bispicolylamine (BiPicA) e.g. Lewatit® MonoPlusTP 220	Tri-n-butylammonium **Lewatit® TP 106**
			
Cyanex 272 impregnated Lewatit® TP 272	Aminomethylphosphonic acid (AMPA) Lewatit® MonoPlus TP 260	Thiourea Lewatit® MonoPlus TP 214	Complex amine Lewatit® A 365(weak base) Lewatit® TP 107 (strong base)

Overview of LANXESS resins and adsorbers for wastewater applications

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Portfolio of selected LANXESS products

Pollutant		Chelating resin		Strong base anion resin (SBA)		Weak base anion resin (WBA)	Ferric hydroxide adsorber	Polymer adsorber
		Lewatit® MonoPlus TP 207	Lewatit® MonoPlus TP 214	Lewatit® K 6362	**Lewatit® TP 108 Lewatit® MonoPlus TP 109**	Lewatit® MP 62 WS	Bayoxide® E IN 20 / E IN 30	Lewatit® VP OC 1064 MD PH
Heavy metals	HM	■						
Mercury	Hg^{2+}		■					
Molybdate, Vanadate	MoO_4^{2-} VO_4^{3-}			■		■		
PFAS					■			
Arsenic	AsO_4^{3-}						■	
Phosphate	PO_4^{3-}						■	
Micropollutants								■

Key design properties of selective Lewatit® TP 108 DW

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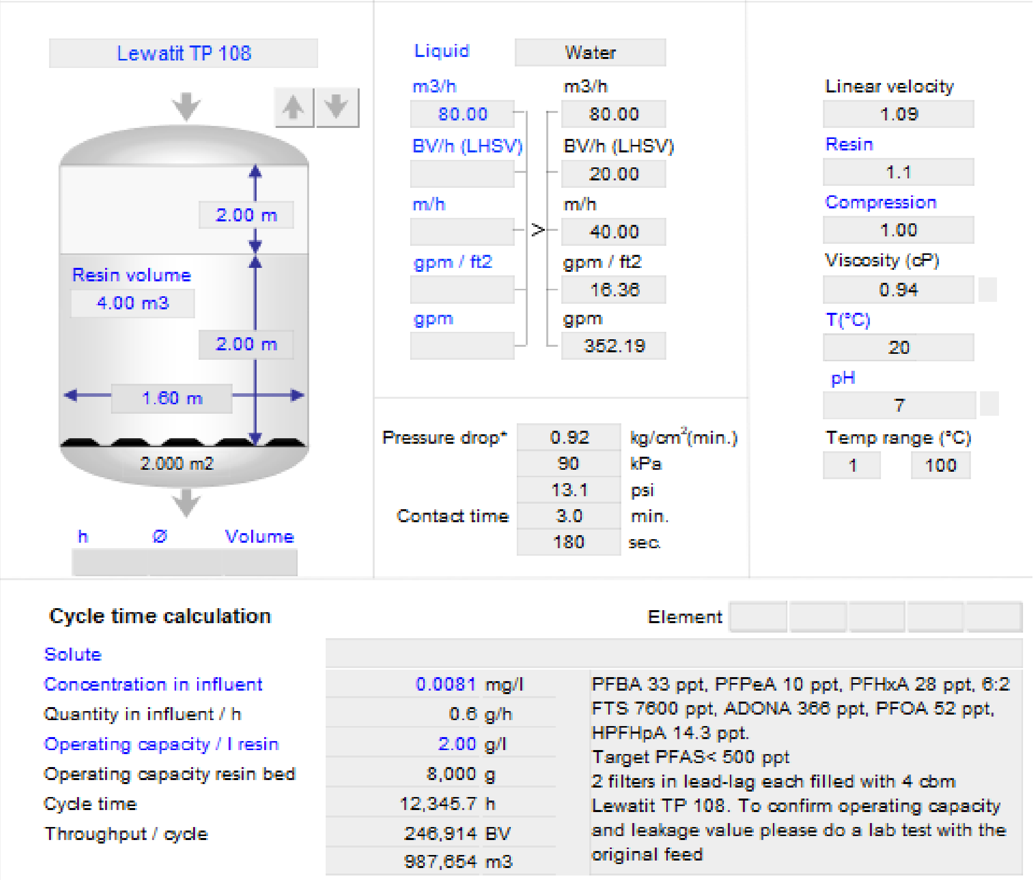
Precise control of resin parameters for critical separation challenges

- 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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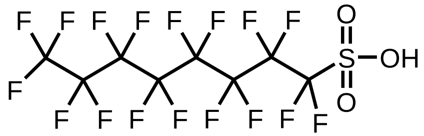
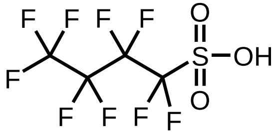
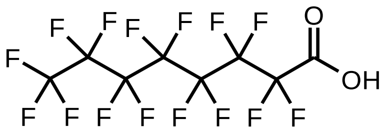
Highly efficient resin for the removal of toxic anions such as perchlorate, chlorate, and bromate



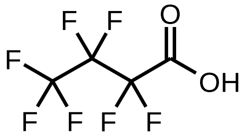
Perfluorooctanesulfonic acid (PFOS)
MW = 500 g/mol



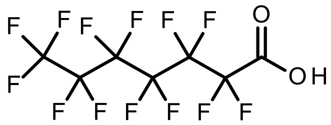
Perfluorobutanesulfonic acid (PFBS)
MW = 300 g/mol



Perfluorooctanoic acid (PFOA)
MW = 414 g/mol



Perfluorobutanoic acid (PFBA)
MW = 214 g/mol



Perfluoroheptanoic acid (PFHpA)
MW = 364 g/mol

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

PFAS Regulations

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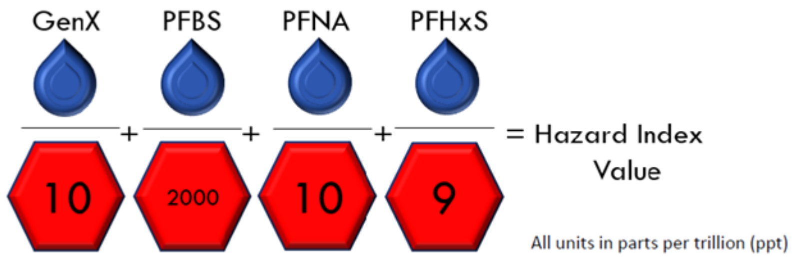
Federal NPDWR Levels (EPA, March 2023)

EPA's Proposed Action for the PFAS NPDWR

Compound	Proposed MCLG	Proposed MCL (enforceable levels)
PFOA	zero	4.0 ppt*
PFOS	zero	4.0 ppt*
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)		

The Hazard Index is a tool used to evaluate potential health risks from exposure to chemical mixtures.



- Now in public hearing stage
- Previous health advisory level set in 2016 is 70 ppt (PFOA + PFOS)

Hazard Index Calculation

- Example 1
  - 5 ppt GenX, 100 ppt PFBS, 1.8 ppt PFNA and 3 ppt PFHxS
  - $Hazard\ Index = \frac{5}{10} + \frac{100}{2000} + \frac{2}{10} + \frac{1.8}{9} = 0.95 < 1$
  - Below MCL
- Example 2
  - 2 ppt GenX, 1000ppt PFBS, 1 ppt PFNA and 2.7 ppt PFHxS
  - $Hazard\ Index = \frac{2}{10} + \frac{1000}{2000} + \frac{1}{10} + \frac{2.7}{9} = 1.1 > 1$
  - Above MCL

https://www.epa.gov/system/files/documents/2023-03/PFAS%20NPDWR%20Public%20Presentation_Overview_3.16.23_508.pdf

US and EU State PFAS Regulations

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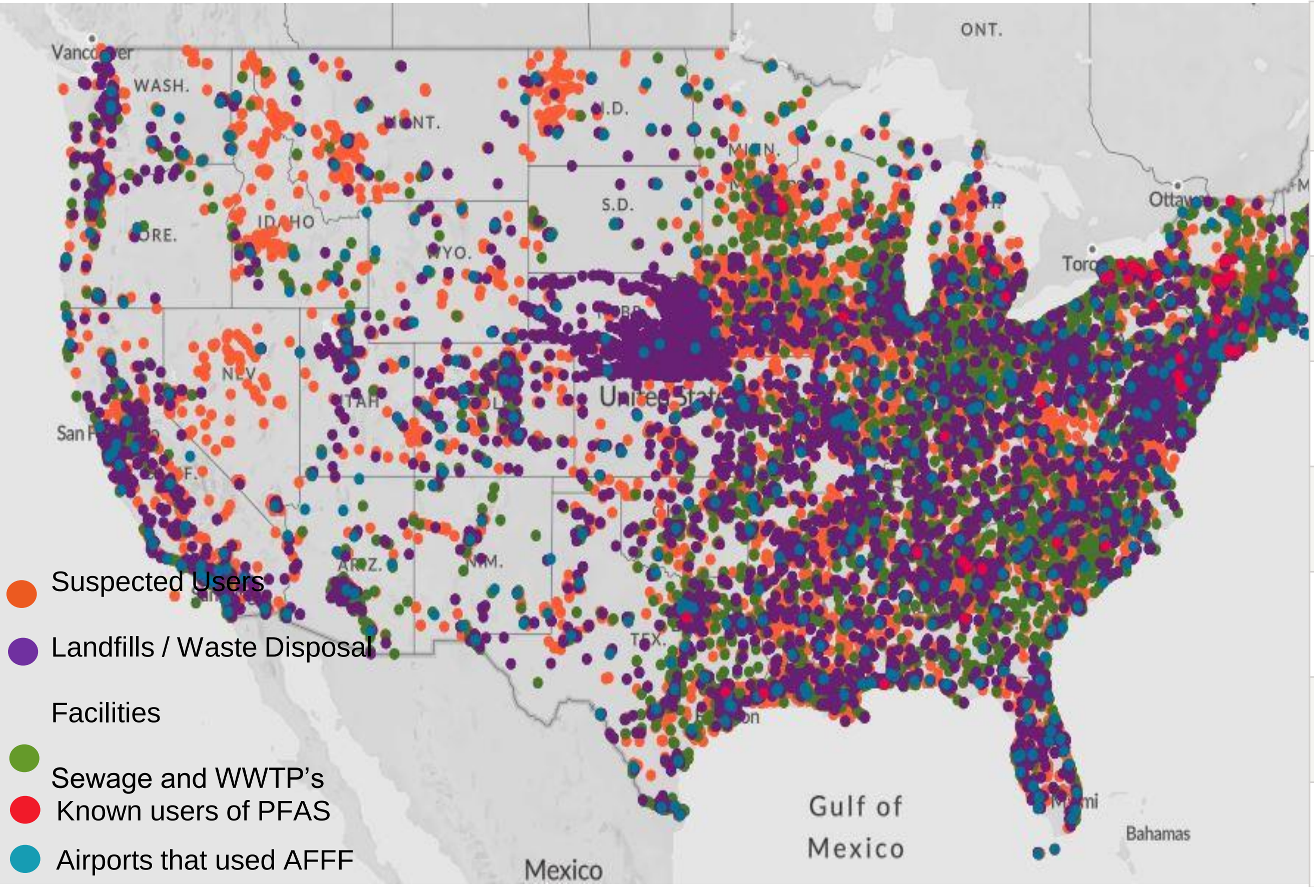
Selective States	State limits
Massachusette	**Drinking Water MCLs**: PFOS, PFOA, PFHxS, PFNA, PFHpA and PFDA (20ppt combined)
Illinois	**Health advisory levels**: PFOS (14ppt), PFOA (2ppt), PFHxA (560,000ppt), PFHxS (140ppt), PFBS (2100ppt).
Connecticut	**Drinking Water Action levels**: PFOA, PFOS, PFNA, PFHxS and PFHpA (70 ppt combined)
New Jersey	**Drinking Water MCLs and Groundwater Quality Standards**: PFOA (14 ppt), PFOS (13 ppt) and PFNA (13 ppt)
North Carolina	**Groundwater Quality Standard**: PFOA and PFOS (70 ppt combined) **Drinking Water Health Goal**: GenX (150 ppt)
Pennsylvania	**Proposing Drinking Water MCLs**: PFOA (14 ppt) and PFOS (18 ppt)
California	**Drinking Water Notification Levels**: PFOS (6.5 ppt), PFOA (5.1 ppt), PFBS (500 ppt) Drinking Water Response Levels: PFOS (40 ppt), PFOA (10 ppt), PFBS (5000 ppt)
Colorado	**Surface water/Groundwater Translation Levels**: PFOA, PFOS and PFNA (70 ppt combined), PFHxS (700 ppt) and PFBS (400,000 ppt).
Maine	**Interim Drinking Water MCLs**: PFOS, PFOA, PFHpA, PFNA, PFHxS and PFDA (20 ppt, combined)
Michigan	**Drinking Water MCLs**: PFNA (6ppt), PFOA (8 ppt), PFHxA (400,000 ppt), PFOS (16 ppt), PFHxS (51 ppt), PFBS (420 ppt), and hexafluoropropylene oxide dimer acid (HFPO-DA) (370 ppt).
Minnesota	**Health Advisory Levels**: PFOS (15 ppt), PFOA (35 ppt), PFHxS (47 ppt), PFBS (2,000 ppt), and PFBA (7,000 ppt).
New Hampshire	**Drinking Water MCLs and Groundwater Quality Standards**: PFOA (12 ppt), PFOS (15 ppt), PFNA (11 ppt), and PFHxS (18 ppt).
New York	**Drinking Water MCLs**: PFOA (10 ppt) and PFOS (10 ppt).
Ohio	**Drinking Water Action Levels**: PFOA and PFOS (70 ppt, combined), GenX (700 ppt), PFBS (140,000 ppt), PFHxS (140 ppt), and
Rhode Island	**MCLs standard:** 20 ppt individually or combined for six PFAS (PFOA, PFOS, PFHxS, PFNA, PFHpA, PFDA).
Vermont	**Drinking water MCLs:** PFOS, PFOA, PFHxS, PFNA, and PFHpA (20 ppt, combined).
Wisconsin	**Surface water MCLs**: PFOS (bioaccumulative, 8 ppt for all water), and PFOA (non-bioaccumulative, 20 ppt for public drinking water source and 95 ppt for all other waters)

State	State limits
EU	current- 2026 $PFAS_{total}$ 500ppt or $PFAS_{20}$ 100 ppt, from 2026 $PFAS_{20}$ 100 ppt, from 2028 $PFAS_4$ 20 ppt
Denmark	$PFAS_4$ 2 ppt
Sweden	$PFAS_4$ 4 ppt, $PFAS_{21}$ 100 ppt,

What about Tennessee?

- PFAS in Tennessee: A Forever Chemical (cumberlandrivercompact.org)
- See Tennessee Riverkeeper, Inc. v. **3M Co.**, No. 5:16-cv01029-AKK, 2017 WL 784991 (N.D. Ala. Feb. 10, 2017) for contaminated local landfills
- 136 DW sites tested, only less than 10 with detectable levels TDEC
- Tennessee sample points EPA UCMR5 Results (arcgis.com)
- Arnold AFB in Manchester, TN with a combined total of 175,000 ppt for PFOS+PFOA in groundwater, 375 notices sent to local landowners.
- Interactive Map: PFAS Contamination Crisis: New Data Show 5,021 Sites in 50 States (ewg.org)

PFAS contamination affects at least 15 Mio people in the USA



PFA	Location detected	Maximum Level (ppt) Years tested
PFBS	Groundwater On-base	190 2019
PFHpA	Groundwater On-base	210 2019
PFHxS	Groundwater On-base	2,000 2019
PFNA	Groundwater On-base	25 2019
PFOA	Groundwater On-base	630 2019
PFOS	Groundwater On-base	4,300 2019
PFOS+PFOA	Groundwater On-base	4,930 2019

Details: Mcghee Tyson Airport, Blount County, TN, Suspected source AFFF

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

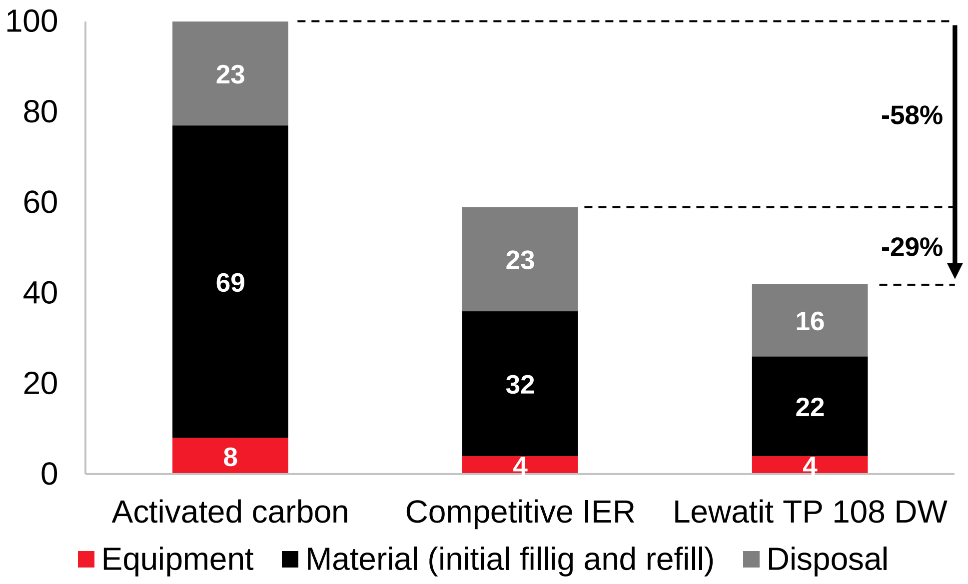
- Low-cost media, however difficult to change and expensive to reactivate
- Engineering system large footprint
- Low selectivity short chain PFAS results short cycles frequent exchanges

Ion exchange

- **Fast kinetics, small vessels, lower EBCT**
- **Spent material is easy to be exchanged**
- **Very high selectivity, long cycles, low exchange rate**
- **Approved for Drinking Water, and effective for waste-water treatment**

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

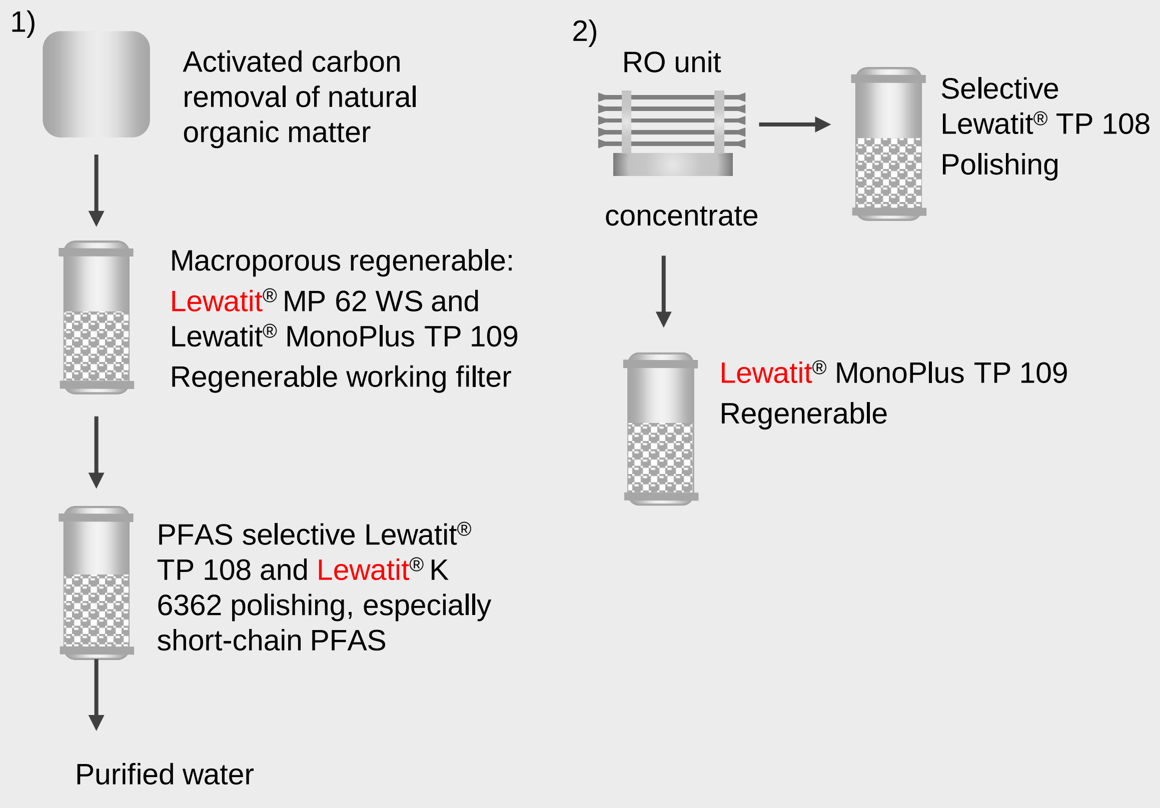
Costs in %
Normalized to GAC costs



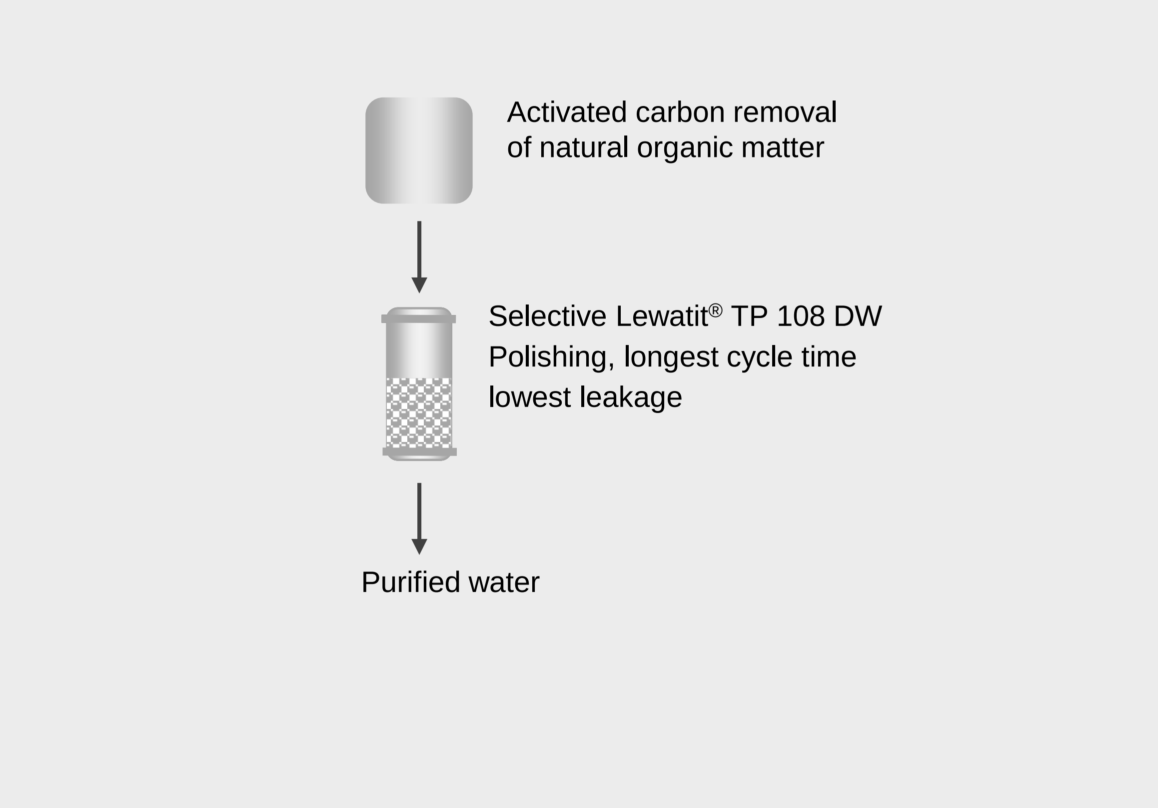
Required resins and filter arrangements

PFAS selective Lewatit resins are present in various water flow sheets

Wastewater leachates from hot spots (PFAS influent: ppm-ppb)



Ground water (PFAS influent: ppt)



Required resins and filter arrangements

PFAS selective Lewatit resins are present in various water flow sheets

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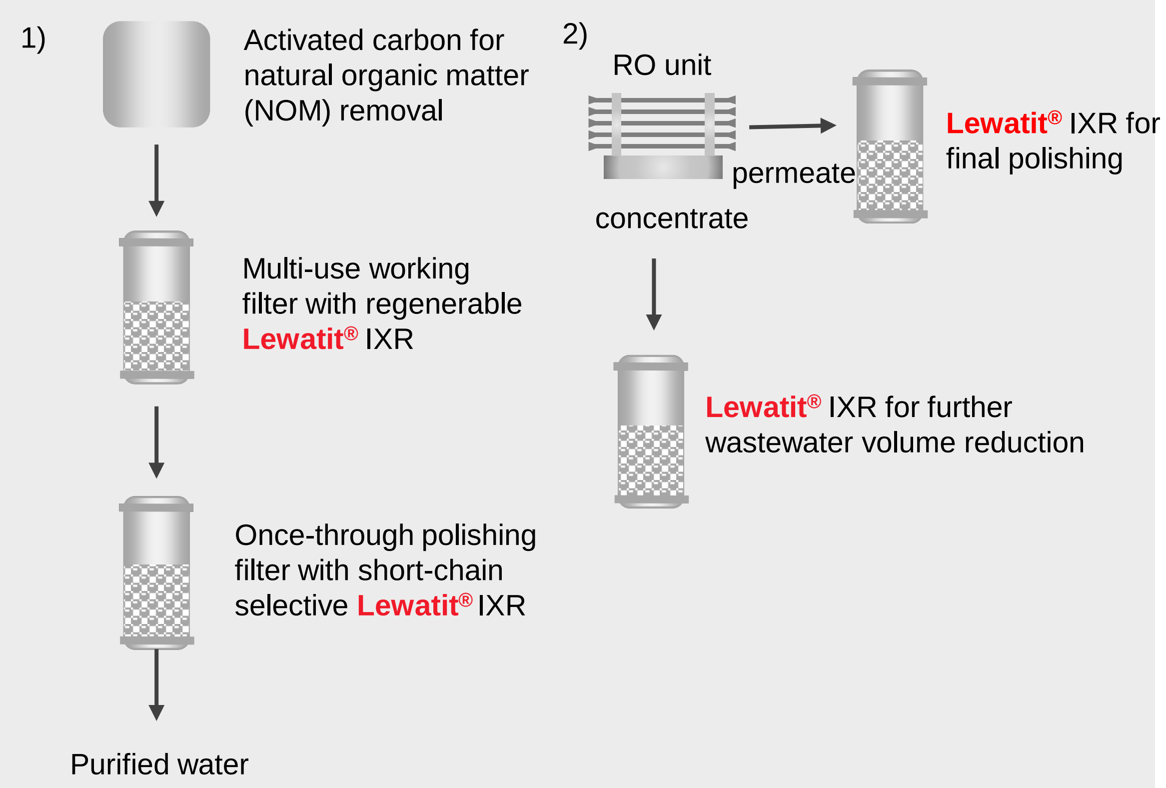
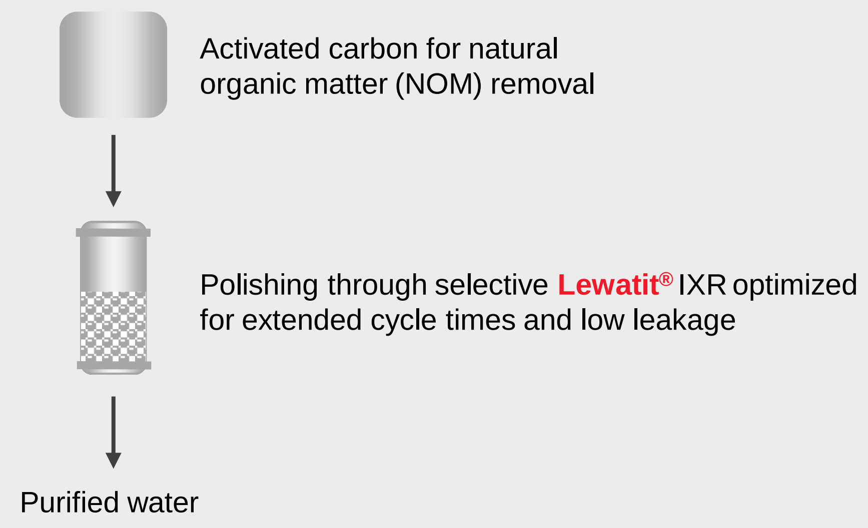
1. Wastewater hot spots (PFAS influent: ppm-ppb range)



2. Groundwater remediation (PFAS influent: ppt range)



Lewatit® PFAS resins

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Lewatit® TP 108 DW (NSF 61)

- **Very high selectivity to PFAS**
- Especially effective against short-chains, e.g., PFBA types
- Not recommended for regeneration
- NSF 61 Certified for drinking water application

Lewatit® MonoPlus TP 109 (New)

- **High selectivity to PFAS species**
- Macroporous structure for improved kinetics, **fouling resistance, and easier regeneration**
- **Monodisperse resin bead size** for improved hydraulics
- Optimum functional group hydrocarbon chain length for balance PFAS removal and regeneration
- High regeneration efficiency 70% methanol + 1% NaCl[1]

Lewatit® MP 62 WS

Lewatit® MP 62 WS Eco (New)

- Medium selectivity for PFAS species weak base anion exchange resin, short chains **regenerated NaOH**
- Suitable for highly PFAS-contaminated waters such as point sources or aquifers
- Macroporous structure for improved kinetics, fouling resistance, and easier regeneration
- A high operating capacity and total capacity (≥1.7 eq/l), ideal as a pretreatment resin
- 24% greenhouse gas savings[2] due to usage of ISCC[2] Plus certified styrene in accordance with mass balance approach

[1] Deng et al. Water Research 2010, 44, 5188

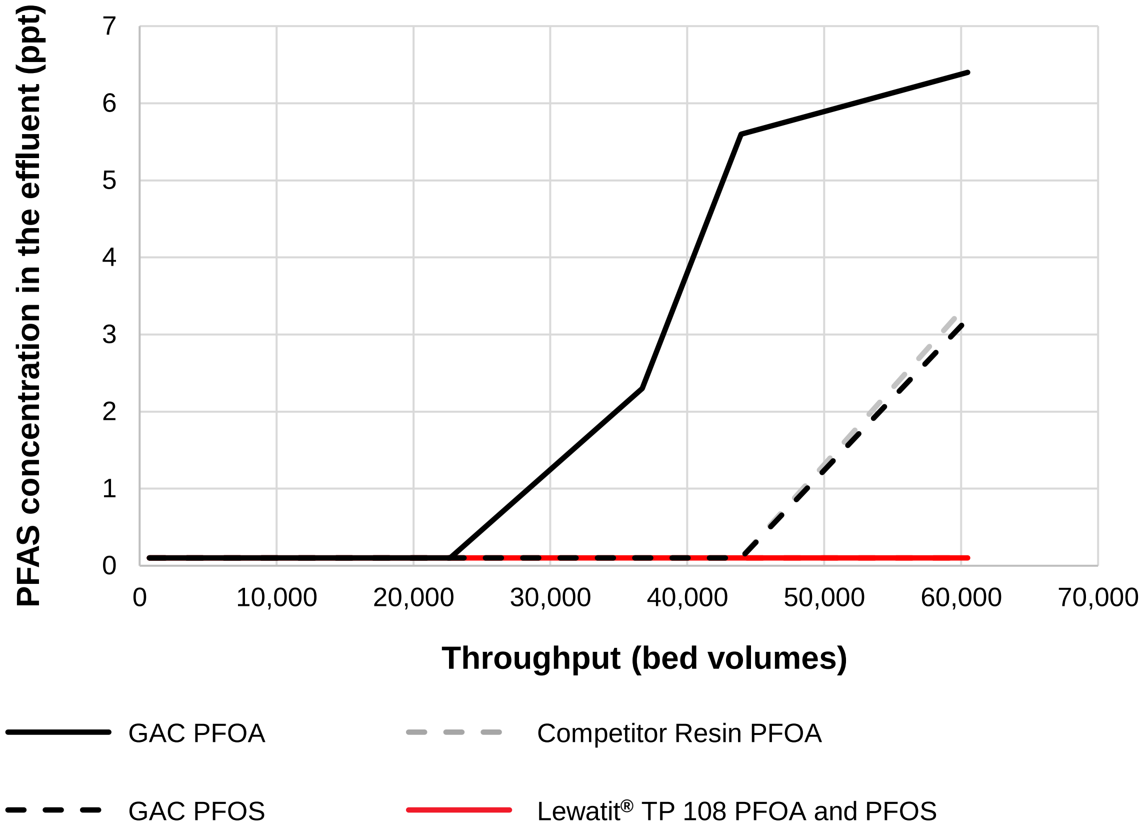
[2] Compared to standard Lewatit® based on fossil monomer (acrylonitrile/styrene). ISCC refers to International Sustainability & Carbon Certification

Pilot: PFOA and PFOS removal from ground water

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

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



Interactions of PFAS with anion exchange resins

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

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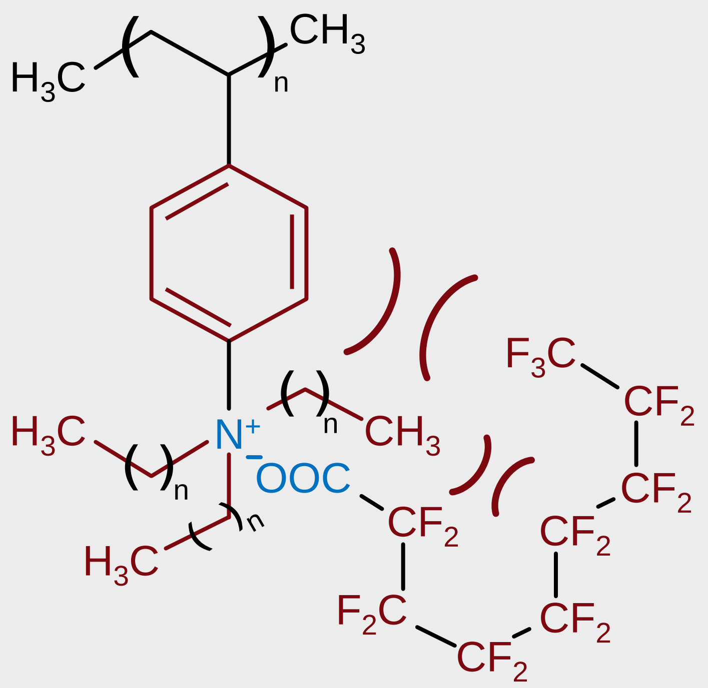
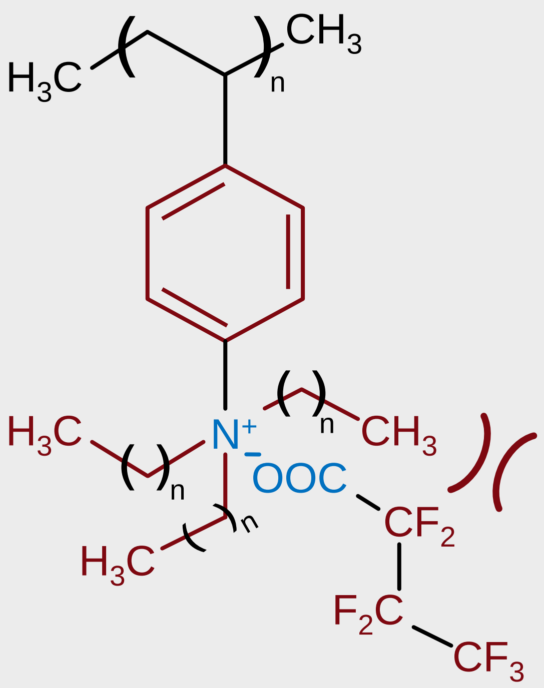
Strong interactions between Lewatit® TP 108 DW and PFNA



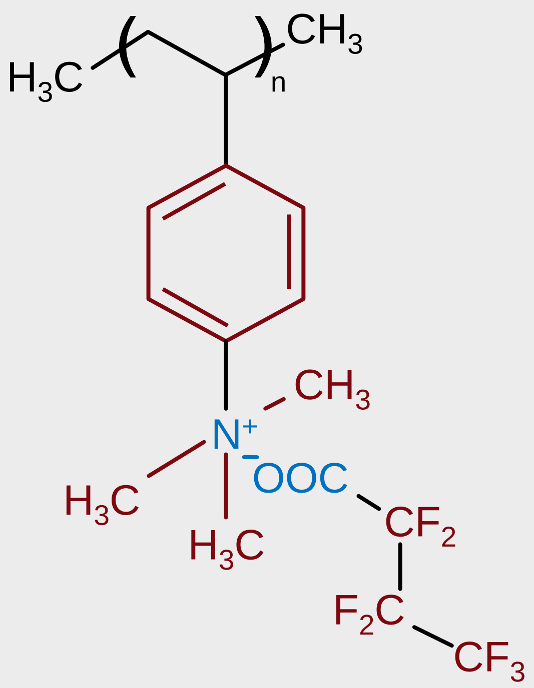
)(Hydrophobic interaction

Medium interactions between Lewatit® TP 108 DW and PFBA



n > 1

Weak interaction between Lewatit® K 6362 and PFBA



+ - Ionic interaction

Full Scale System: Long lifetime of Lewatit® TP 108 DW even at high PFAS influent concentration

LANXESS Energizing Chemistry

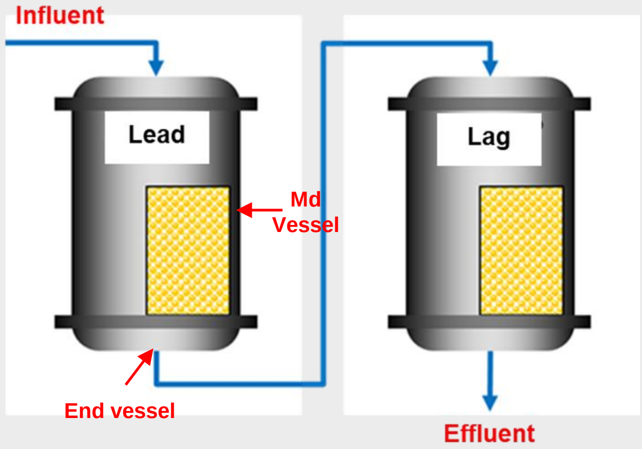
Drinking Water Production, Township NJ USA

- Lead/lag: 200 cu ft resin in each vessel (8'x12')

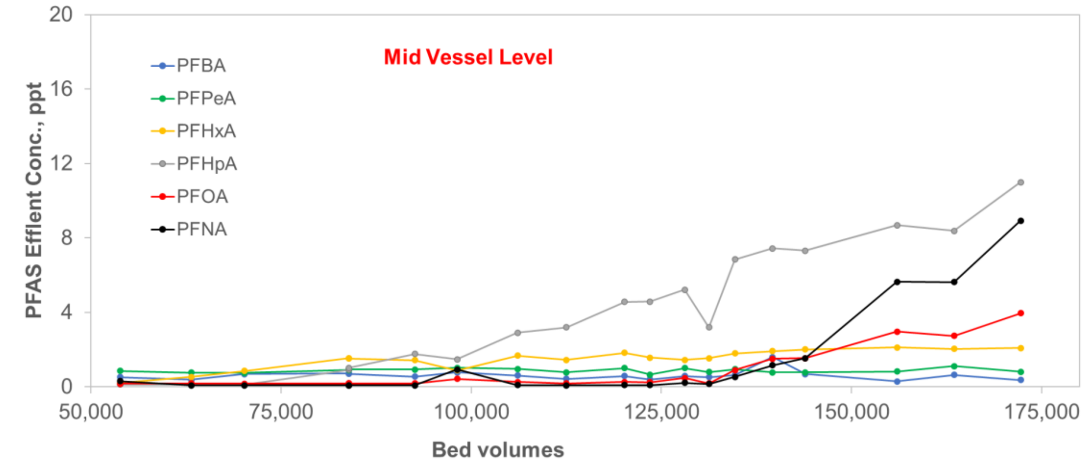
Raw water, ppt

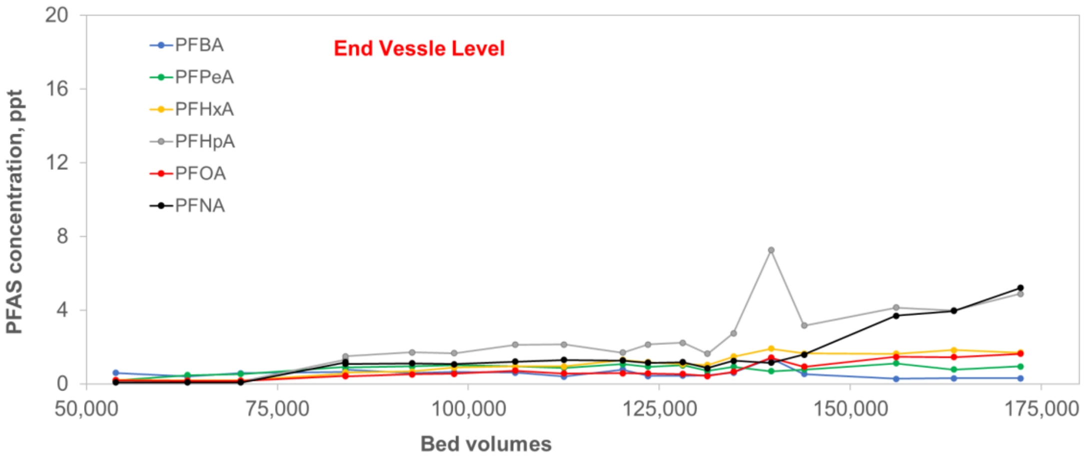
Sample Date	PFOA	PFNA	PFBA	PFPeA	PFHxA	PFHpA
Jan, 2022	10.1	67.4	0.6	0.8	1.3	11.4
Nov, 2022	16.7	114	0.6	0.9	1.9	12.6
Feb, 2023	21.3	162	0.9	1.3	3.1	17.5
Average	16.0	114.5	0.7	1.0	2.1	13.8

Alkalinity, ppm as $CaCO_3$	109
Chloride, ppm	34.8
Nitrate + Nitrite, ppm	Non detect
Nitrate, ppm	Non detect
Sulfate, ppm	44.9
TOC, ppm	0.136



In Operation for 2 Years





Pilot: PA Township Installation

Installation

- Installed & started up on 10/12/2023 by LANXESS
- Lewatit TP 108 DW technical and safety sheets provided to the township
- Regular flow/totalizer checks by LANXESS personnel in cooperation with the township Control group
- Monthly effluent sampling of both columns
- DOD (CIV USN) approved paying for additional pilot samples analysis
- LANXESS – The Township arranged and paid for analysis using Eurofins using EPA Method 533
- Flow rate was targeted for 750 ml/min, and was adjusted during each visit
- Influent and effluent pressures consistent (no head pressure build-up)

Design Criteria

Parameters	Pilot	Current Operation
Diameter	2 inch	5 ft
Bed depth	2.42 ft	3 ft
Volume of resin	1.49 liters (0.053 cu ft)	1671 liters (59 cu ft)
Volumetric flow rate	750 ml/min (0.2 gpm)	321 liter/min (85 gpm)
Hydraulic flow rate	22 m/h (9 gpm/sqr ft)	10.5 m/h (4.3 gpm/sqr ft)
EBCT	2 min	5.2 min
Specific velocity	30 BV/hr	11.5 BV/hr

Pilot: PA Township Comparative Results: PFAS

All values in ppt	Column 1 (a competitor's PFAS resin, the incumbent)												
Time	Estimated BVs	PFBA	PFPeA	PFOS	PFHxA	PFOA	PFDA	PFHxS	PFBS	PFHpA	PFNA	4:2 FTS	6:2 FTS
10/12/2023	0			429	80	174	1	210	24	35	8		
10/18/2023	5567	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
11/27/2023	40346	48	55	<2	6.8	<2	<2	<2	<2	<2	<2	<2	<2
01/08/2024	82035	39	91	<2	44	17	<2	2	<2	6.5	<2	2.1	24
02/09/2024	106974												

All values in ppt	Column 2 (Lanxess Lewatit® TP 108 DW)												
Time	Estimated BVs	PFBA	PFPeA	PFOS	PFHxA	PFOA	PFDA	PFHxS	PFBS	PFHpA	PFNA	4:2 FTS	6:2 FTS
10/12/2023	0			429	80	174	1	210	24	35	8		
10/18/2023	5393	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9
11/27/2023	38906	46	52	<2	5.4	<2	<2	<2	<2	<2	<2	<2	<2
01/08/2024	79843	36	81	<1.9	37	5.6	<1.9	<1.9	<1.9	3.7	<1.9	2	19
02/09/2024	104362												

- TP 108 performed slightly better across all species and significantly better on PFOA @ ~ month 4

Pilot: Summary and Next Steps with Lewatit TP 108 DW

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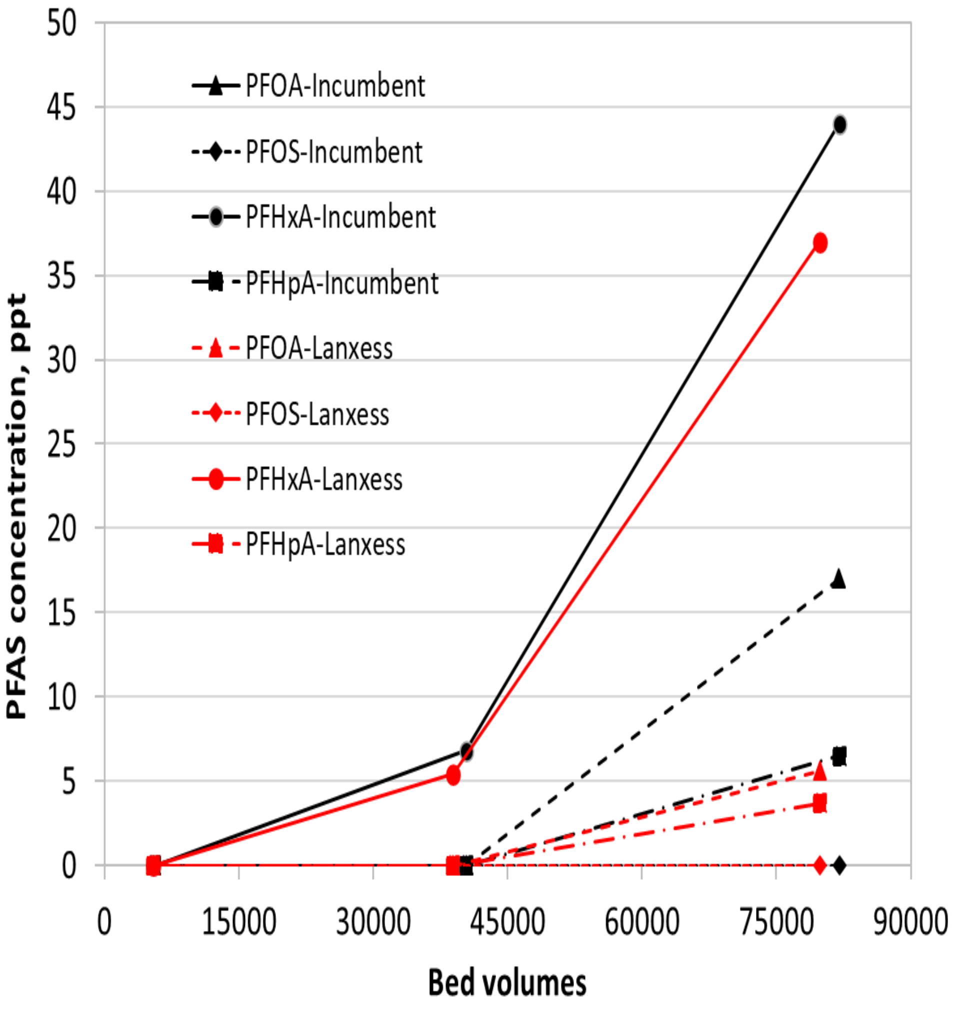

Summary

- TP 108 DW performed slightly better than the incumbent competitor's resin
- Flow rate variations were recorded
- Average EBCT = 1.8 min
  - Compared to the current operation of 5.2 min EBCT
- Average specific flow rate = 33.3 BV/hr
  - Compared to current operation of 11.5 BV/hr

→ Much shorter EBCT, faster breakthrough and accelerated comparative pilot study

Next Steps

- Analyze one more data point for further confirmation
- Obtain raw water data (TOC, inorganic ions, TSS, TDS, pH, etc.) from the township
- Obtain more recent Short-chain species concentration data from the township
- Is approval required by DoD? If so, submit data
- Is approval needed by PA DEP? If so, submit data
- Timeline full-scale conversion (next change out date)?

Long lifetime of Lewatit® TP 108 DW even at high PFAS influent concentration

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Energizing Chemistry

Pilot Trial in a River Water Project, USA

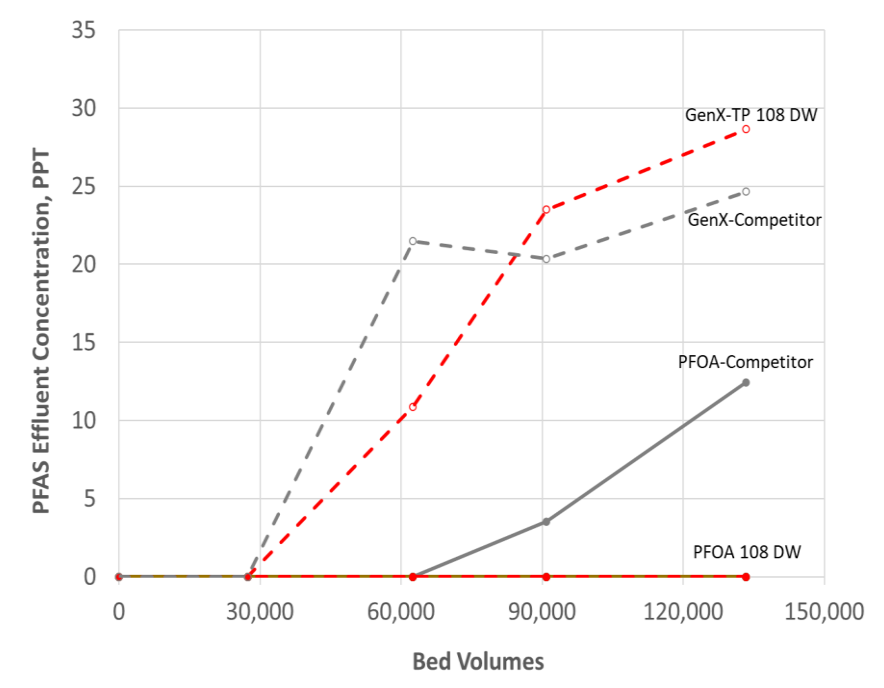
- 20 BV/Hour -> EBCT = 3 min
- Competitor resin is a gel-type non-regenerable PFAS resin

IX Resins	Bed Volumes	PFOS, ppt	PFOA, ppt	PFBS, ppt	PFHxS, ppt	PFNA, ppt	GenX, ppt	PFHxA, ppt	PFHpA, ppt
	Raw Water	20.8	23.5	6.1	9.3	5.9	28.7	64.9	42.5
TP 108 DW	27,400	ND	ND	ND	ND	ND	ND	ND	ND
TP 108 DW	62,500	ND	ND	ND	ND	ND	10.9	7.8	ND
TP 108 DW	90,900	ND	ND	ND	ND	ND	23.5	37.0	6
TP 108 DW	133,400	ND	ND	ND	ND	ND	28.7	68.7	11.5
A Competitor Resin	27,400	ND	ND	ND	ND	ND	ND	ND	ND
A Competitor Resin	62,500	ND	ND	ND	ND	ND	21.5	16.9	2.5
A Competitor Resin	90,900	ND	3.5	ND	ND	ND	20.3	37.6	15.7
A Competitor Resin	133,400	ND	12.5	ND	ND	ND	24.6	50.6	26.3

ND: non-detect

PFOA and GenX Removal

- PFOA (feed) = 23.5 ppt; GenX (feed) = 28.7 ppt



Long lifetime of Lewatit® TP 108 DW even at high PFAS influent concentration

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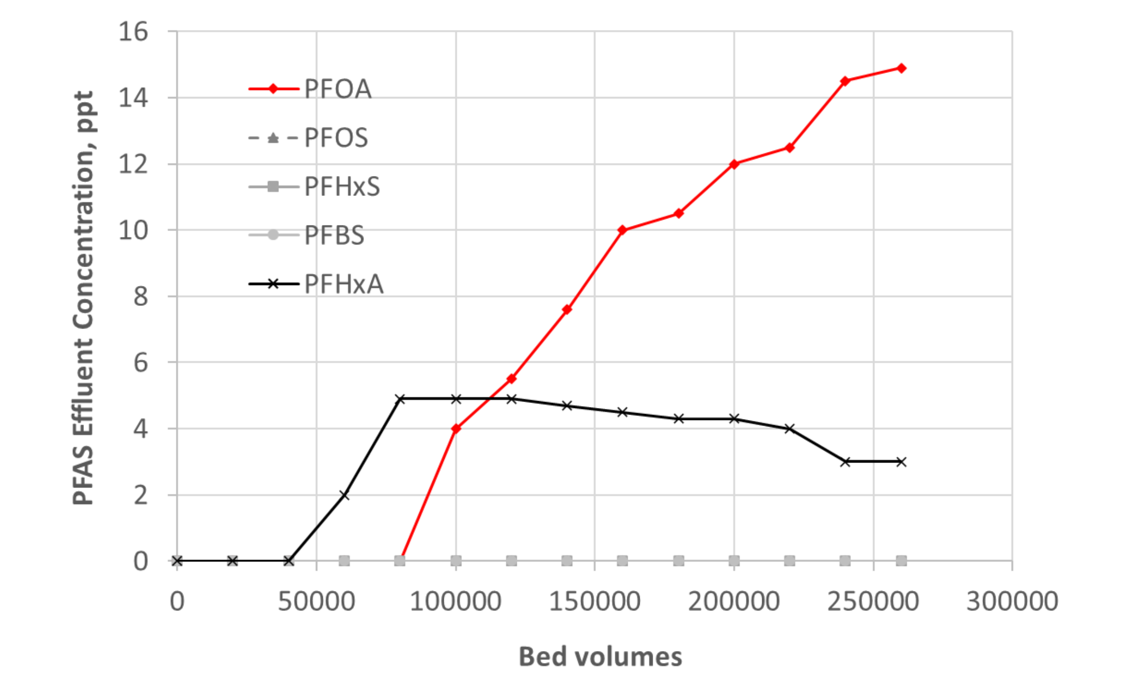
California OCWD Pilot Data (Phase 2)

- 30 BV/hour, run for about 19 months
- EBCT = 2min

Bed Volumes (BV)	PFOA	PFOS	PFHxS	PFBS	PFHxA
Avg. Influent conc., ppt	20.1	24.5	10.3	14.9	4.5
0	ND	ND	ND	ND	ND
20,000	ND	ND	ND	ND	ND
40,000	ND	ND	ND	ND	ND
60,000	ND	ND	ND	ND	2
100,000	4	ND	ND	ND	4.9
140,000	7.6	ND	ND	ND	4.7
180,000	10.5	ND	ND	ND	4.3
220,000	12.5	ND	ND	ND	4
260,000	14.9	ND	ND	ND	3

19 Month Trial

- PFOS, PFHxS and PFBS didn't breakthrough



ND: non-detect

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

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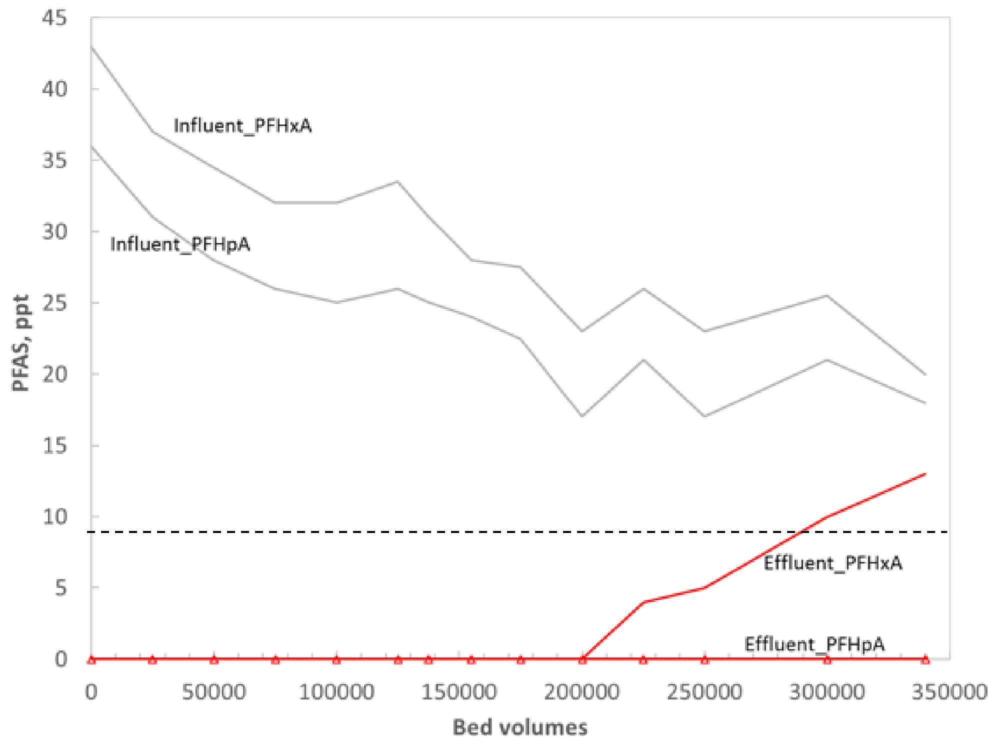
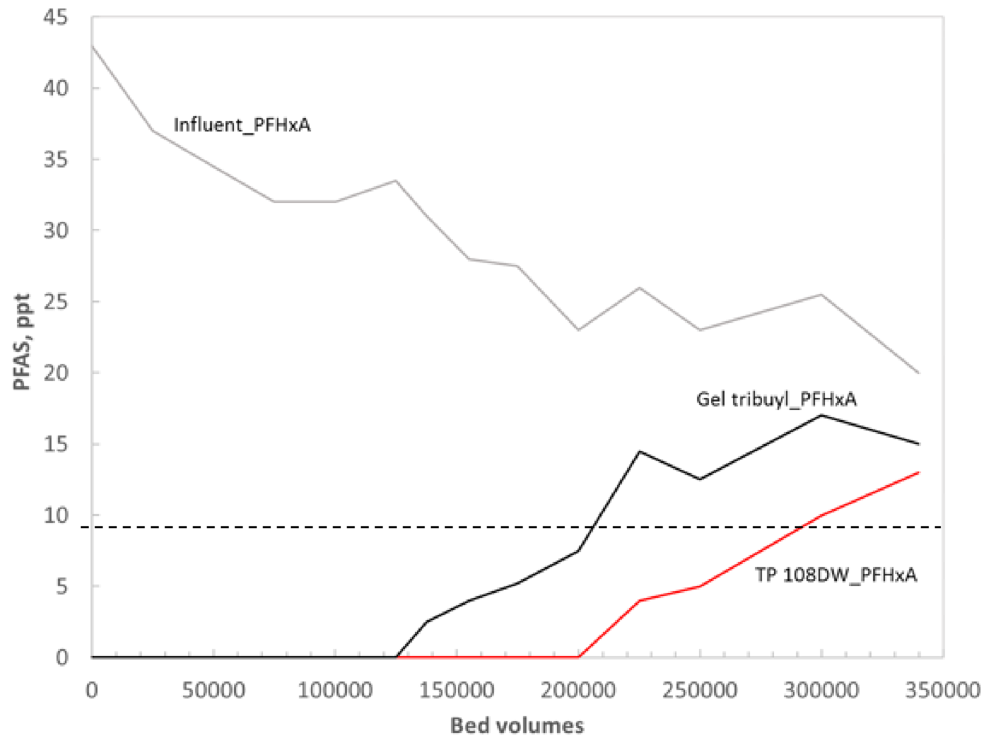
PFHxA and PFHpA breakthrough curves generated USA



PFHxA breakthrough curves generated USA



Resin performance for PFAS application

Fast access to breakthrough curves by Klinkenberg simulation

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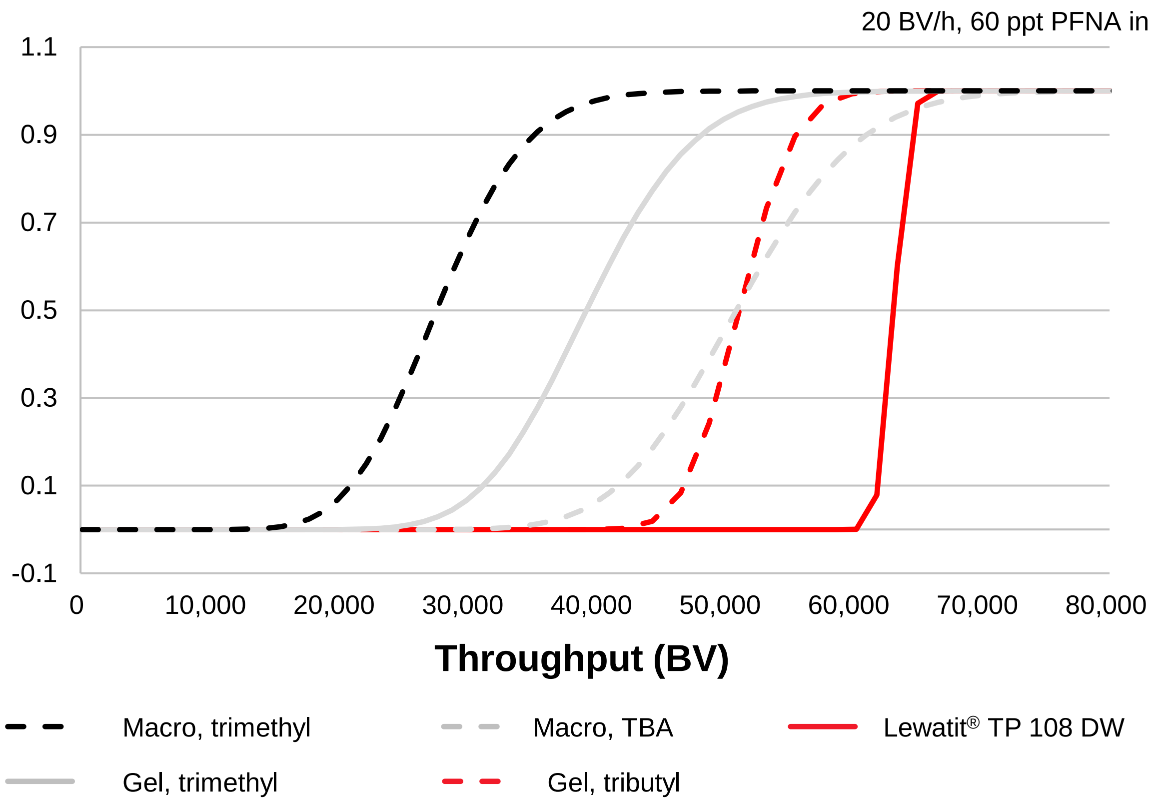
PFNA breakthrough curves



Conclusions

- Lewatit® TP 108 DW best resin to be used as single-use polisher: longest cycle time and lowest leakage
- Macroporous resins, shorter cycle times, and higher leakage values due to lower total capacity
- Technique established that yields fast access to breakthrough curves 2-3 weeks instead of 15 weeks for a traditional method

$$\frac{C}{C_f} \approx \frac{1}{2}\left[1 + erf\left(\sqrt{\tau_1} - \sqrt{\xi} + \frac{1}{8\sqrt{\tau_1}} + \frac{1}{8\sqrt{\xi}}\right)\right]$$

$$\xi = \frac{kKu}{z}\left(\frac{1-\varepsilon_b}{\varepsilon_b}\right) \qquad \tau_1 = k\left(t - \frac{z}{u}\right)$$

Case study at fire training site Australia

One of the most successful PFAS water treatment plants

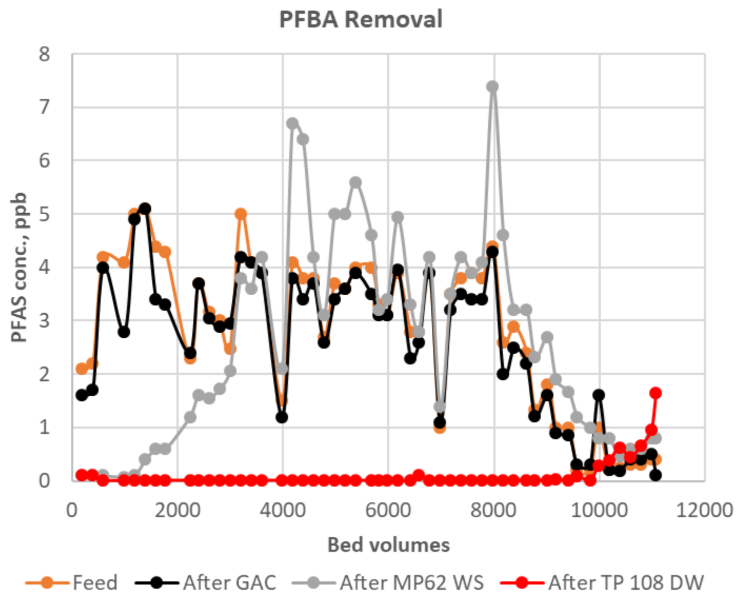
Containerized PFAS treatment plant

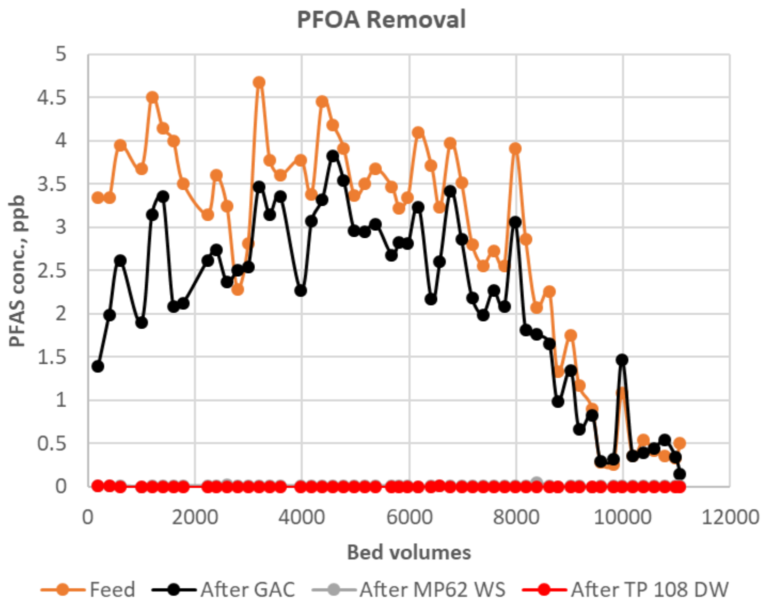
Characteristics

- 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

Efficient short-chain PFAS removal only with Lewatit® TP 108 DW!





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

Operational Guidelines

Tips and trick on how to improve resin performance!

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Recommended Operational Conditions

- Total suspended solids in the feed < 0.5 ppm
- Pressure drop <150kpa to prevent mechanical stress on the resins
- Free chlorine < 0.05 ppm: effective pre-treatment is recommended to prevent irreversible chemical damage to the resins
- Presence of other oxidants e.g., ozone, permanganate and etc are not tolerable- same as above
- Organic as TOC < 1 ppm: effective pre-treatment is required to prevent fouling of the resins and prevent poor performance
- Oil & grease are not tolerable- same as above
- Heavy metals: <0.05 ppm

Design Considerations

- Specific flow rate: 10-20 BV/hour
- Vessels: 8 ft, 12 ft diameter vessels are typical
- Cross-sectional linear velocity: > 5 m/hour
- Bed depth: minimum 3 ft
- Backwash: not recommended except startup
- Pretreatments
  - High TOC: GAC, Acrylic resin pre-filter
  - High PFAS concentration: regenerable resins as pre-filters
- Configuration
  - Lead/lag

Micropollutant removal by municipal water treatment

Lewatit® VP OC 1064 MDPH has high loading capacities and stripping efficiencies

- Removal of micropollutants planned till 2035 (all plants > 100.000 residents)
- Pharma- and chemical industry must share costs
- Micropollutant = each substance that is harmful to humans or environment
- Longer lifetime of the resin due to higher stability and less frequent regenerations
- First focus on pharmaceuticals and body care products

Selective micropollutant from waste water

High loading and stripping efficiencies with Lewatit® VP OC 1064 MD PH!

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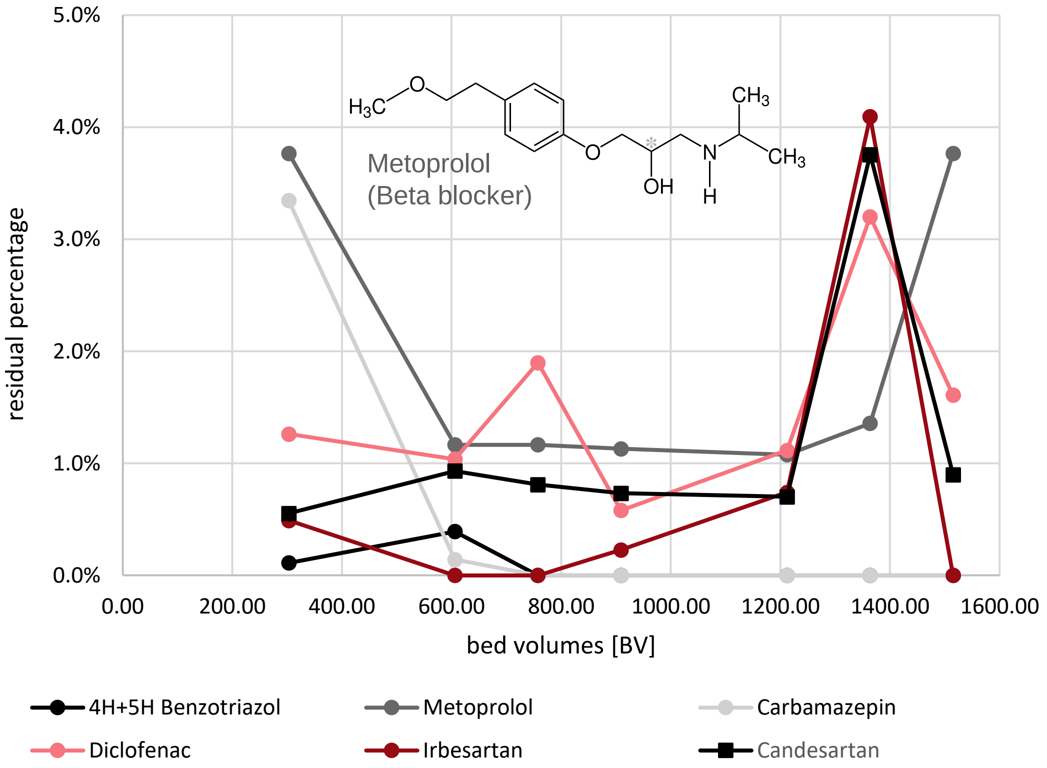
Lewatit® VP OC 1064 MDPH removes aromatic pollutants from effluent of municipal wastewater treatment plant in south Germany.

Loading conditions (feed concentration ppb / loading capacity g/L)	
Benzotriazol 1H	5.7 ppb / > 3.6 g/L
Benzotriazol 4H+5H	0.8 ppb / > 1 g/L
Metoprolol	0.5 ppb / > 0.6 g/L
Carbamazepin	0.3 ppb / > 0.5 g/L
Diclofenac	2.0 ppb / > 2.6 g/L
Irbesartan	0.6 ppb / > 0.8 g/L
Candesartan	0.9 ppb / > 1,1 g/L
pH	7
SV	60 BV/h
Temp	RT
Regeneration conditions	
2 BV acidified methanol	1.5%
SV	1.5 BV/h

In courtesy of Prof. Dr Ruck who performed test work



Benefits

- More efficient than activated carbon (AC): higher loading capacities, less leakage, smaller filters, longer lifetime due to high mechanical stability

→ Savings on CAPEX and OPEX

- Efficient regeneration with methanol. Regenerant can be recovered by distillation. No significant material loss. AC loses appr. 10 % per regeneration.
- Onsite regeneration possible. AC requires transport to a central high temperature treatment plant

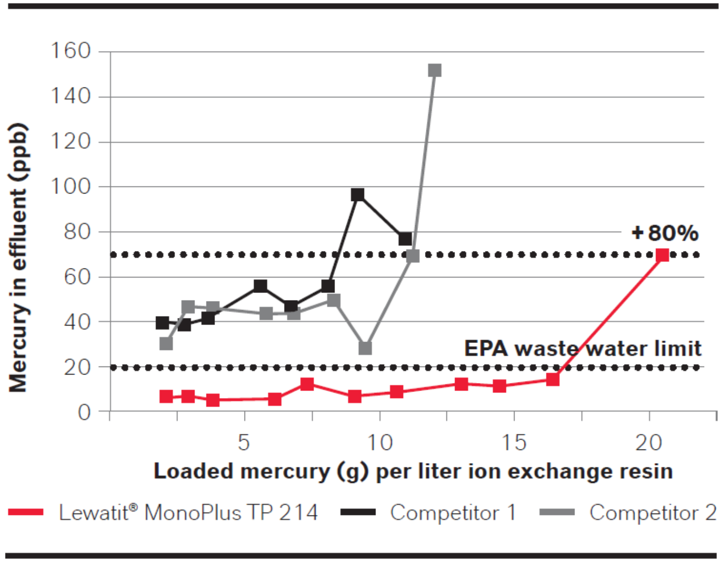
Mercury removal from wastewater streams

Lewatit® MonoPlus TP 214 has lower mercury leakage and 80% longer cycle time than the competition!

Selectivity is the key!

- Save mercury removal below the wastewater discharge limit of 20 ppb (EPA)
- Up to 80% higher mercury removal capacities compared to competitor resins. High recycling efficiency of precious metals
- Long resin lifetime provides savings on capital investment costs
- Legal requirements regarding discharge limits are fulfilled in a cost-efficient manner
- High mercury selectivity provides low leakage after operation and convenient disposal of the single-use resin
- Leakage: below 1 ppb (inlet 40 ppb), below 20 ppb (inlet 400 ppb)
- The resin does not have odour

Lewatit® MonoPlus TP 214 outperforms competition



Feed composition
$[Hg^{2+}]$ = 400 ppb
[NaCl] = 40 g/L
pH = 9

Specific flow = 10 BV/h

LANXESS has the right products and technical expertise for every application

LANXESS Energizing Chemistry

- 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®

For further questions or any other topics, please reach out to us

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