



**LANXESS**  
Energizing Chemistry

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

Dr. Dirk Steinhilber, Technical Marketing Manager  
LANXESS Deutschland GmbH, Business Unit Liquid Purification Technologies

Intersol 2024

# Versatile specialists – comprehensive product portfolio provides advanced solutions

## Products and brands

**X Lewatit®**

**X Lewatit®**  
Scopeblue

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

**X Bayoxide®**

- Granular iron oxide adsorbers for water treatment

**LewaPlus®**

- Software for designing and optimizing ion exchange resin plants

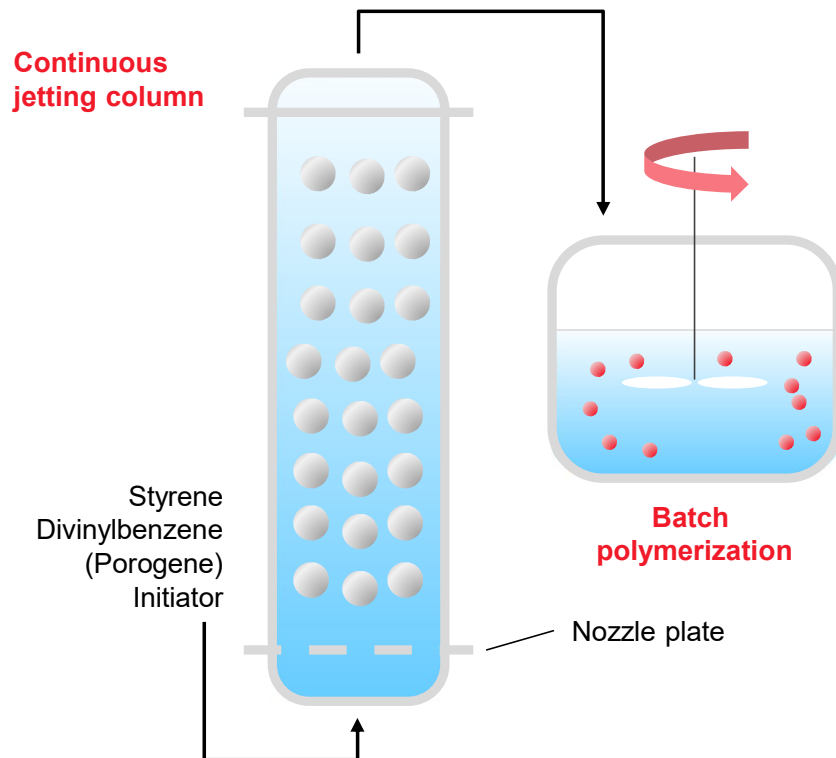
## Customer industries



# Monodisperse droplet generation by jetting process

Stable scaffolds for demanding metals processing applications!

## Formation of monodisperse droplets



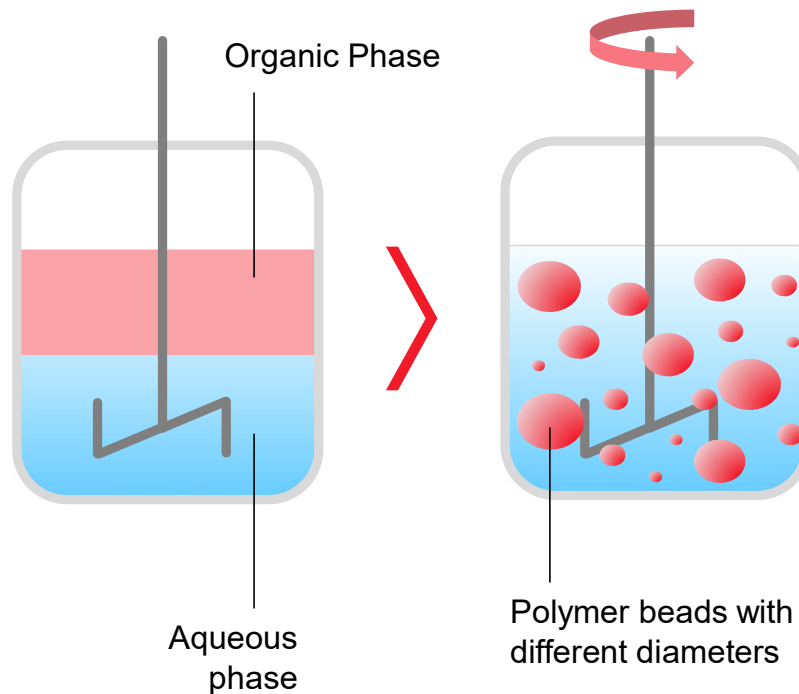
## Description

- 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

## Batch type process

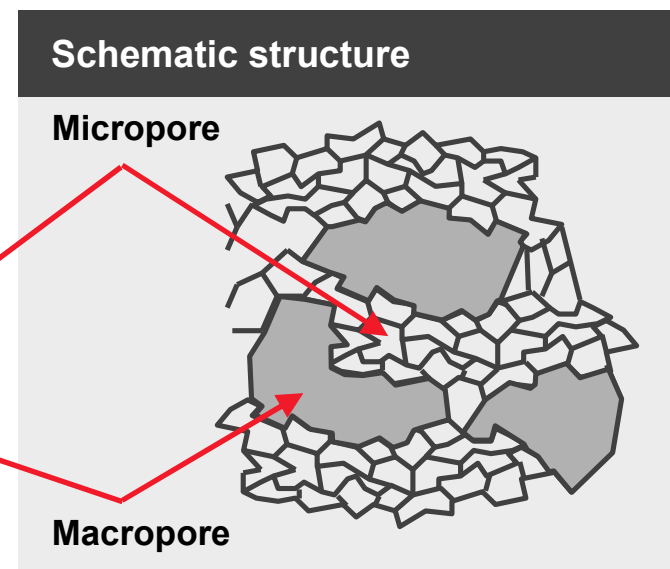
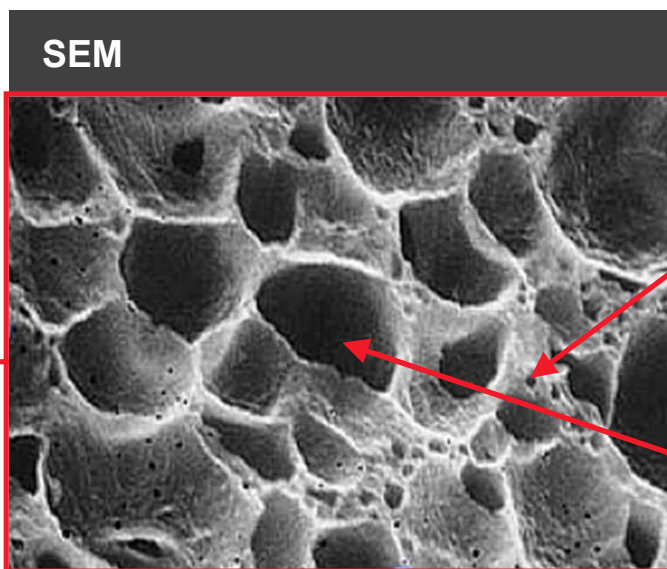
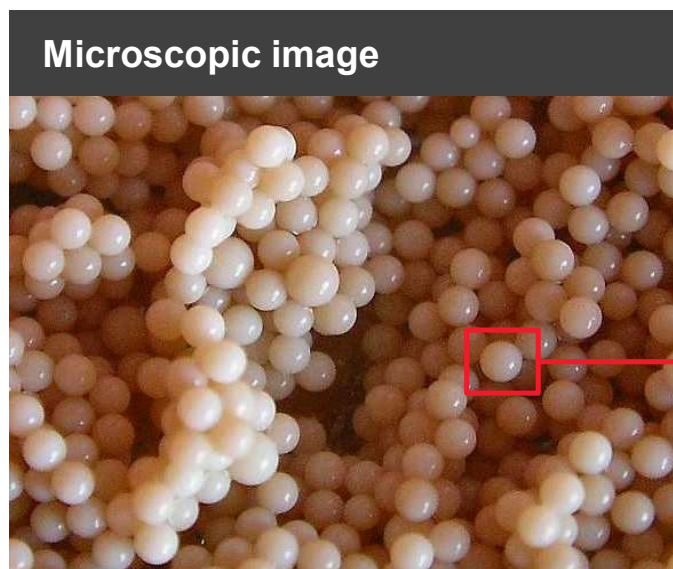


## Description

- 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

# The structure of macroporous resins

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



# Overview of LANXESS resins and adsorbers for wastewater applications



## 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 <sup>2+</sup>		■					
Molybdate, Vanadate	MoO <sub>4</sub> <sup>2-</sup> VO <sub>4</sub> <sup>3-</sup>			■		■		
PFAS					■			
Arsenic	AsO <sub>4</sub> <sup>3-</sup>						■	
Phosphate	PO <sub>4</sub> <sup>3-</sup>						■	
Micropollutants								■

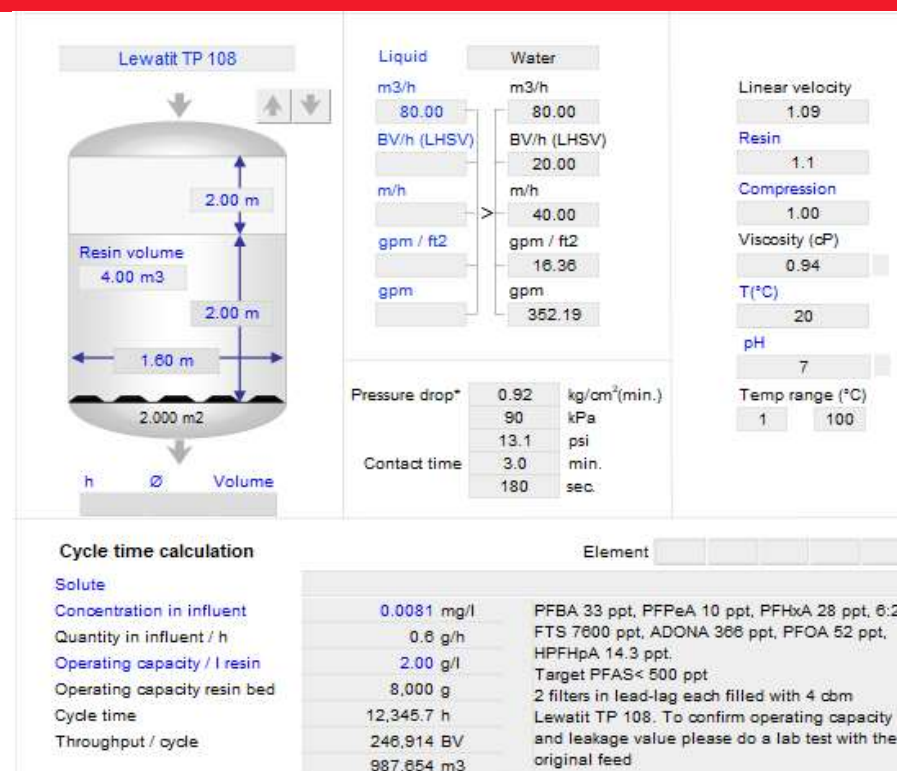


# Key design properties of selective Lewatit® TP 108 DW

## Precise control of resin parameters for critical separation challenges

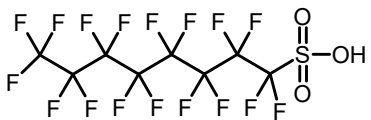
- Functional group (Type of Amine)
- Polymer matrix (Styrenic or Acrylic)
- Morphology (Gel or Macroporous)
- Crosslinking
- Bead size
- Kinetics
- Resin swelling

Uniformity coefficient	1.7
Effective size	0.40-0.55
Fines	1
Total capacity (delivery form)	0.7
Delivery form	Cl <sup>-</sup>
Functional group	quaternary ammonium
Matrix	styrenic
Structure	gel
Appearance	white, opaque



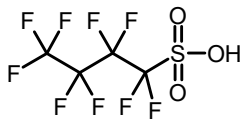
## Chemical structures of most critical PFAS and their sources

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



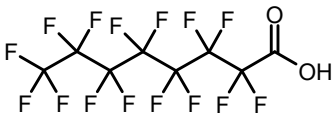
### Perfluorooctanesulfonic acid (PFOS)

MW = 500 g/mol



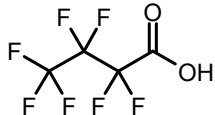
### Perfluorobutanesulfonic acid (PFBS)

MW = 300 g/mol



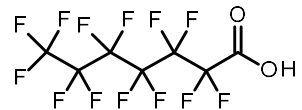
### Perfluorooctanoic acid (PFOA)

MW = 414 g/mol



### Perfluorobutanoic acid (PFBA)

MW = 214 g/mol



### Perfluoroheptanoic acid (PFHpA)

MW = 364 g/mol



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



# US and EU State PFAS Regulations

Selective States	State limits
Massachusetts	<b>Drinking Water MCLs:</b> PFOS, PFOA, PFHxS, PFNA, PFHpA and PFDA (20ppt combined)
Illinois	<b>Health advisory levels:</b> PFOS (14ppt), PFOA (2ppt), PFHxA (560,000ppt), PFHxS (140ppt), PFBS (2100ppt).
Connecticut	<b>Drinking Water Action levels:</b> PFOA, PFOS, PFNA, PFHxS and PFHpA (70 ppt combined)
New Jersey	<b>Drinking Water MCLs and Groundwater Quality Standards:</b> PFOA (14 ppt), PFOS (13 ppt) and PFNA (13 ppt)
North Carolina	<b>Groundwater Quality Standard:</b> PFOA and PFOS (70 ppt combined) <b>Drinking Water Health Goal:</b> GenX (150 ppt)
Pennsylvania	<b>Proposing Drinking Water MCLs:</b> PFOA (14 ppt) and PFOS (18 ppt)
California	<b>Drinking Water Notification Levels:</b> PFOS (6.5 ppt), PFOA (5.1 ppt), PFBS (500 ppt) <b>Drinking Water Response Levels:</b> PFOS (40 ppt), PFOA (10 ppt), PFBS (5000 ppt)
Colorado	<b>Surface water/Groundwater Translation Levels:</b> PFOA, PFOS and PFNA (70 ppt combined), PFHxS (700 ppt) and PFBS (400,000 ppt).
Maine	<b>Interim Drinking Water MCLs:</b> PFOS, PFOA, PFHpA, PFNA, PFHxS and PFDA (20 ppt, combined)
Michigan	<b>Drinking Water MCLs:</b> 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	<b>Health Advisory Levels:</b> PFOS (15 ppt), PFOA (35 ppt), PFHxS (47 ppt), PFBS (2,000 ppt), and PFBA (7,000 ppt).
New Hampshire	<b>Drinking Water MCLs and Groundwater Quality Standards:</b> PFOA (12 ppt), PFOS (15 ppt), PFNA (11 ppt), and PFHxS (18 ppt).
New York	<b>Drinking Water MCLs:</b> PFOA (10 ppt) and PFOS (10 ppt).
Ohio	<b>Drinking Water Action Levels:</b> PFOA and PFOS (70 ppt, combined), GenX (700 ppt), PFBS (140,000 ppt), PFHxS (140 ppt), and
Rhode Island	<b>MCLs standard:</b> 20 ppt individually or combined for six PFAS (PFOA, PFOS, PFHxS, PFNA, PFHpA, PFDA).
Vermont	<b>Drinking water MCLs:</b> PFOS, PFOA, PFHxS, PFNA, and PFHpA (20 ppt, combined).
Wisconsin	<b>Surface water MCLs:</b> 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 <sub>total</sub> 500ppt or PFAS <sub>20</sub> 100 ppt, from 2026 PFAS <sub>20</sub> 100 ppt, from 2028 PFAS <sub>4</sub> 20 ppt
Denmark	PFAS <sub>4</sub> 2 ppt
Sweden	PFAS <sub>4</sub> 4 ppt, PFAS <sub>21</sub> 100 ppt,

# Options for treatment of PFAS

Ion exchange most efficient technology especially for short chain PFAS!

## 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

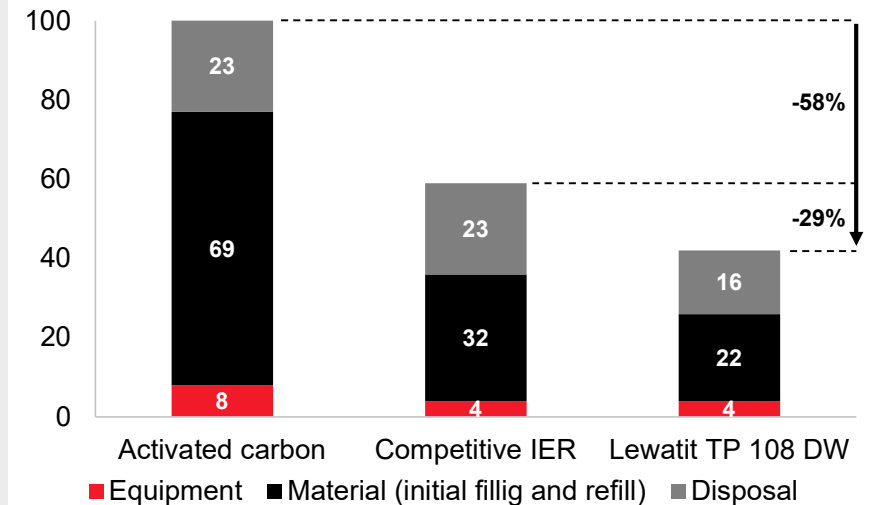
## Ion exchange

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

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

### Costs in %

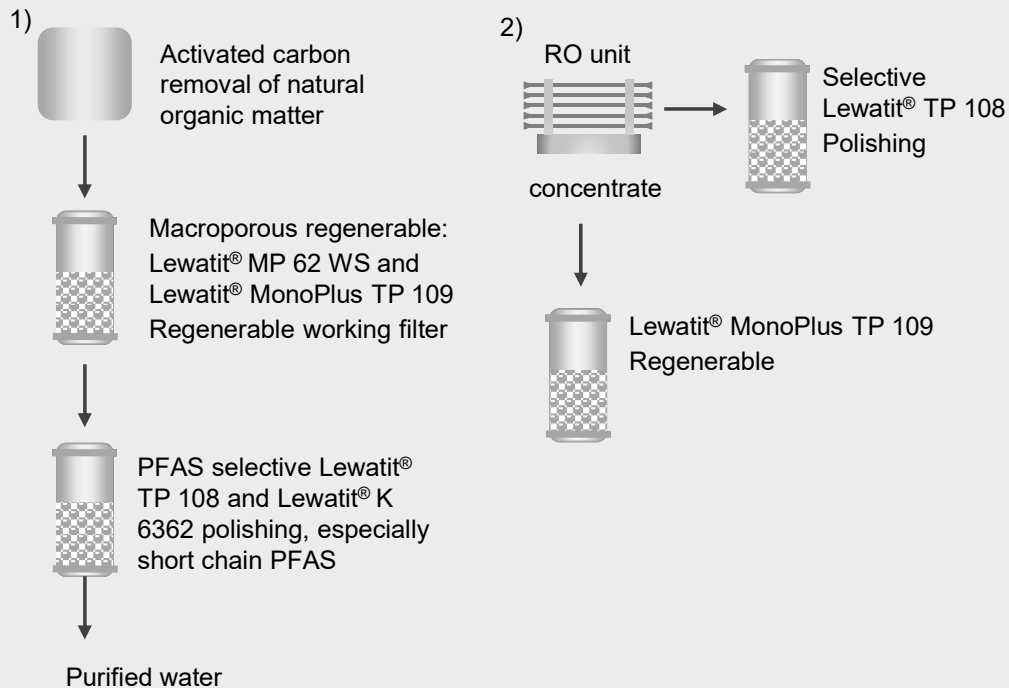
Normalized to AC costs



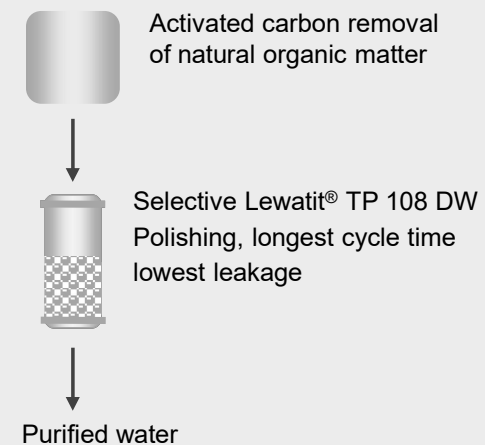
# Required resins and filter arrangements

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)



# Lewatit® PFAS resins

## Lewatit® TP 108 DW



- **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



- **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<sup>[1]</sup>

## Lewatit® MP 62 WS

## Lewatit® MP 62 WS Eco



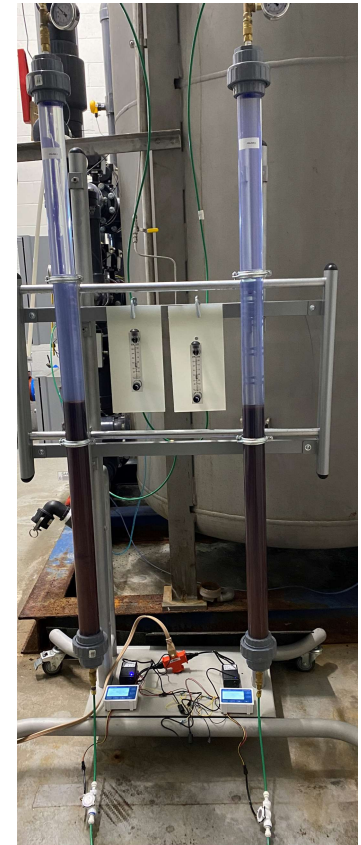
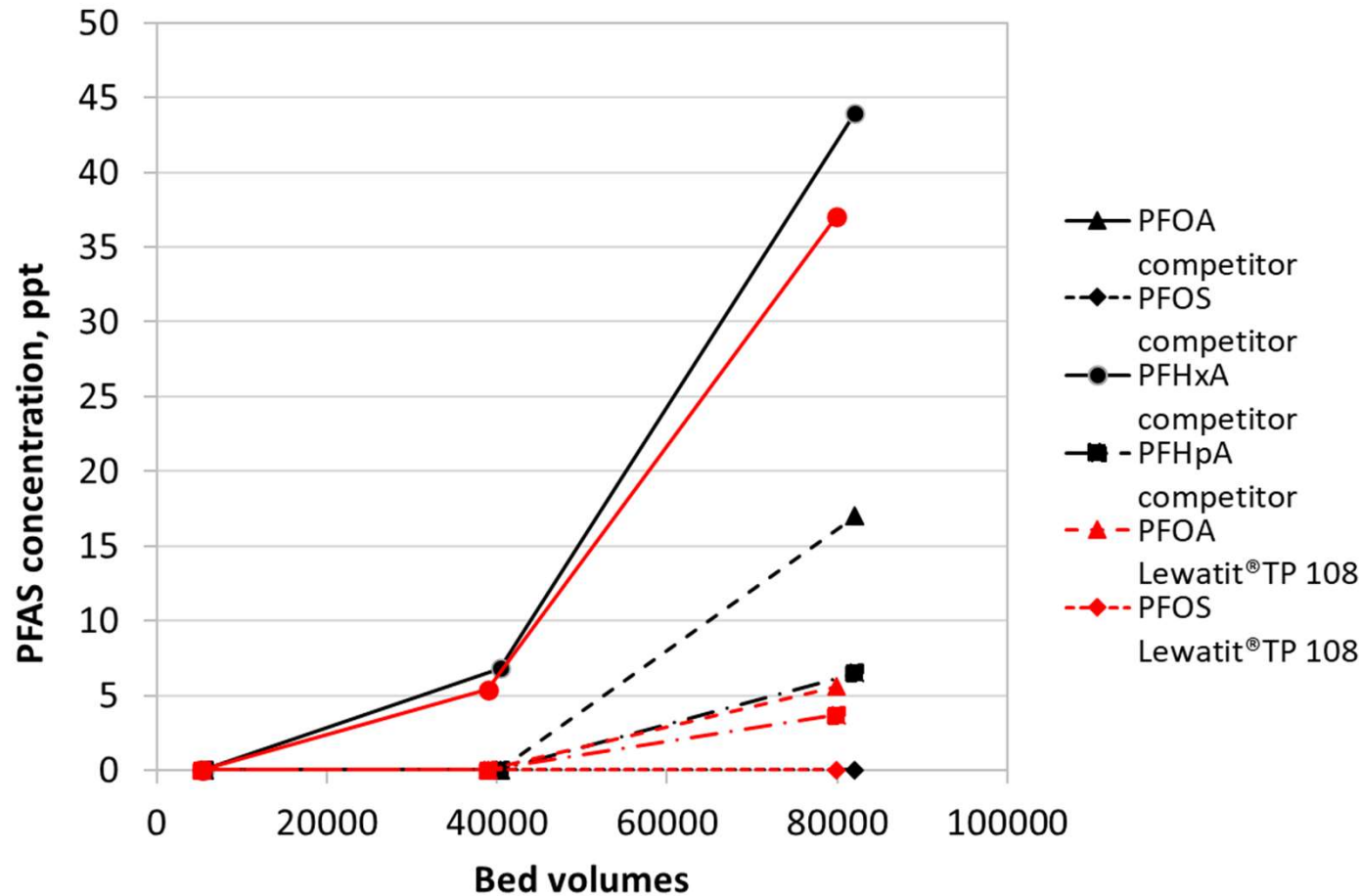
- Medium selectivity for PFAS species weak base anion exchange resin, short chains **regenerated NaOH**
- Suitable for highly PFAS-contaminated waters such as point sources or aquifers
- Macroporous structure for improved kinetics, fouling resistance and easier regeneration
- A high operating capacity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

<sup>1</sup> Deng et al. Water Research 2010, 44, 5188

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

# Warminster Pilot Comparative Results

Lewatit® TP 108 offers longer lifetime than competitor resin



# 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

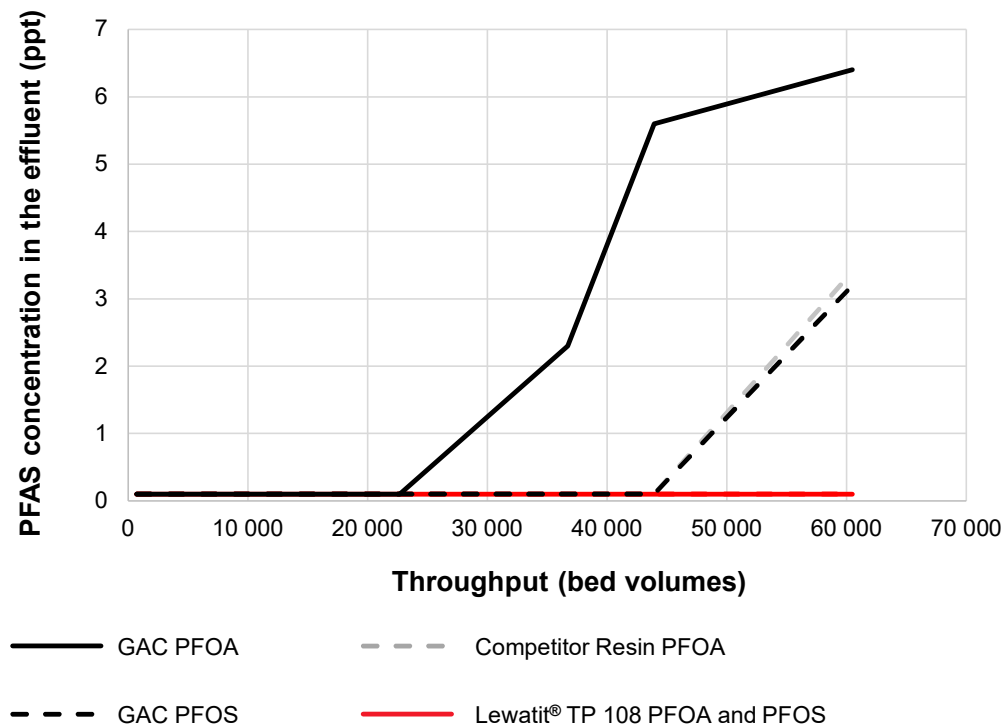
pH 7

SV 15 BV/h

Temp 20°C

Breakthrough > 1 ppt

## PFOA and PFOS removal pilot in Italy

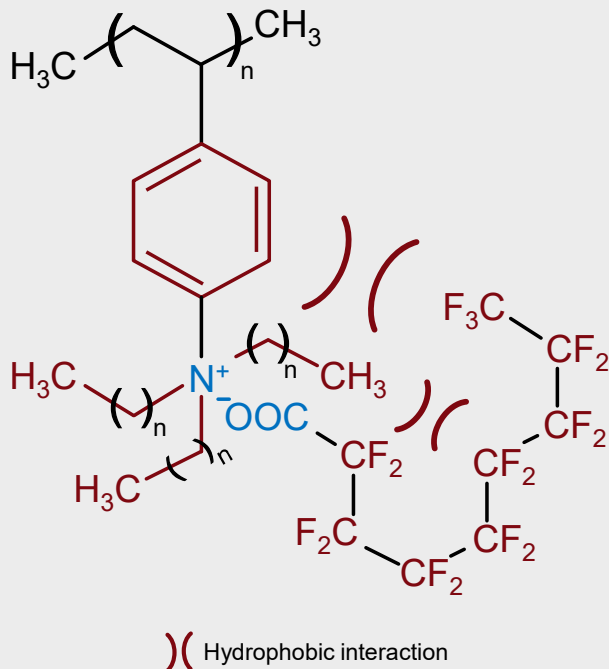




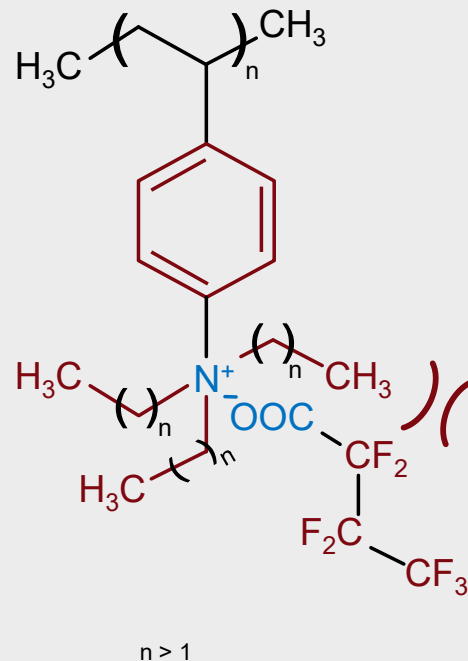
# Interactions of PFAS with anion exchange resins

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

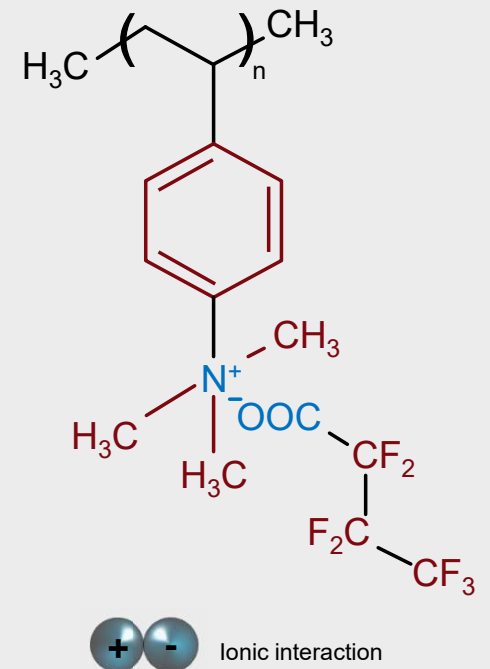
## Strong interactions between Lewatit® TP 108 DW and PFNA



## Medium interactions between Lewatit® TP 108 DW and PFBA



## Weak interaction between Lewatit® K 6362 and PFBA



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

## Pilot Trial in a River Water Project, USA

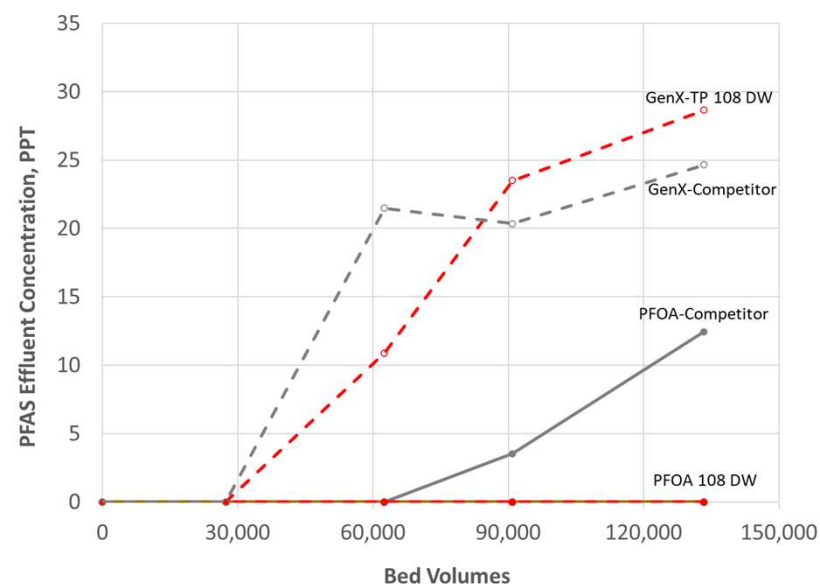
- 20 BV/Hour
- EBCT = 3 min
- Competitor resin is a gel type non-regenerable PFAS resin

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

## California OCWD Pilot Data (Phase 2)

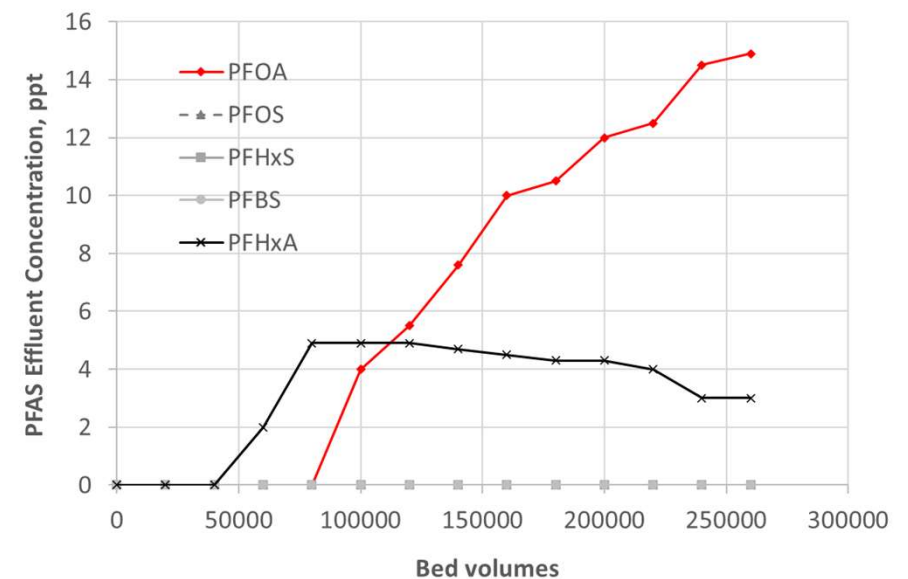
- 30 BV/hour, run for about 19 months
- EBCT = 2min

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
80,000	ND	ND	ND	ND	4.9
100,000	4	ND	ND	ND	4.9
120,000	5.5	ND	ND	ND	4.9
140,000	7.6	ND	ND	ND	4.7
160,000	10	ND	ND	ND	4.5
180,000	10.5	ND	ND	ND	4.3
200,000	12	ND	ND	ND	4.3
220,000	12.5	ND	ND	ND	4
240,000	14.5	ND	ND	ND	3
260,000	14.9	ND	ND	ND	3

ND: non-detect

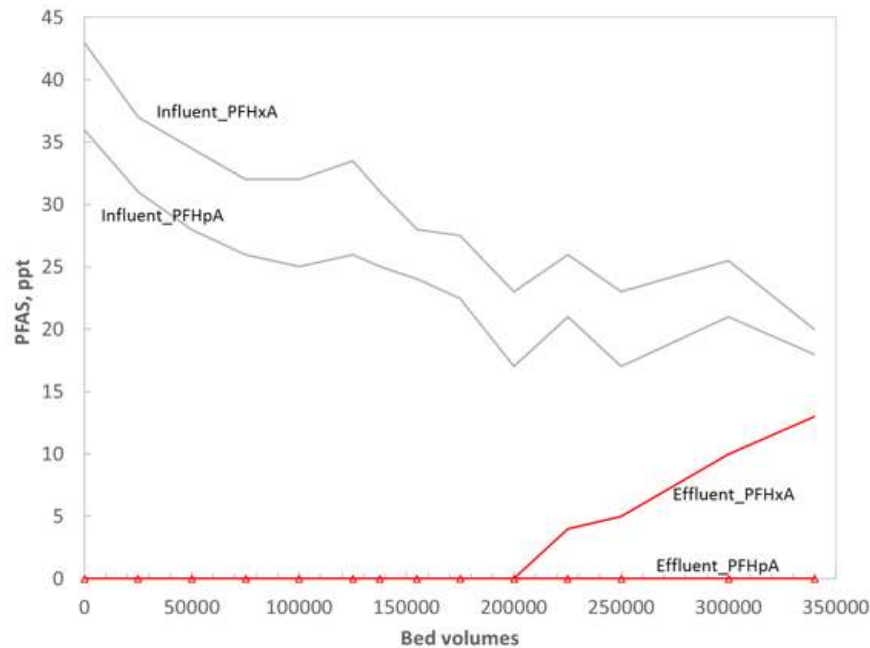
## 19 Month Trial

- PFOS, PFHxS and PFBS didn't breakthrough

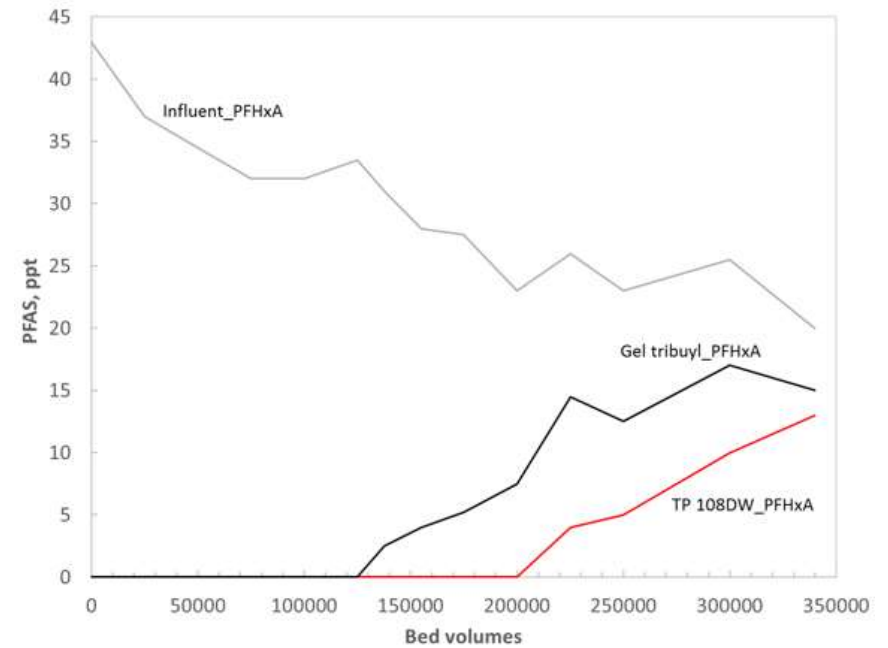


# Lewatit® TP 108 DW offers the highest capacity for most PFAS species found in drinking water sources

## PFHxA and PFHpA breakthrough curves generated USA

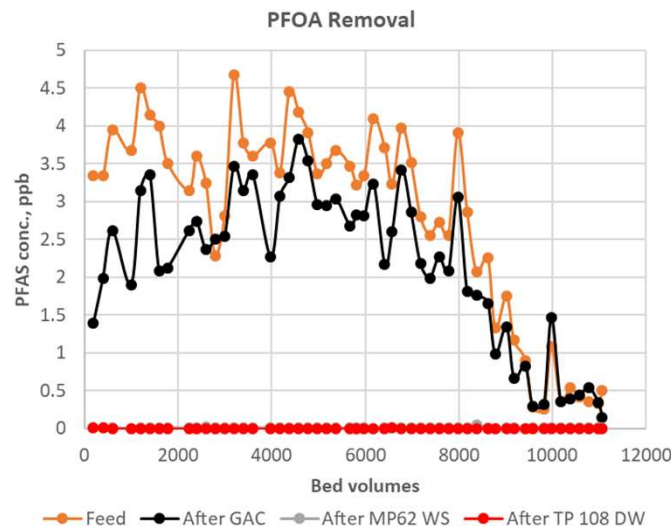
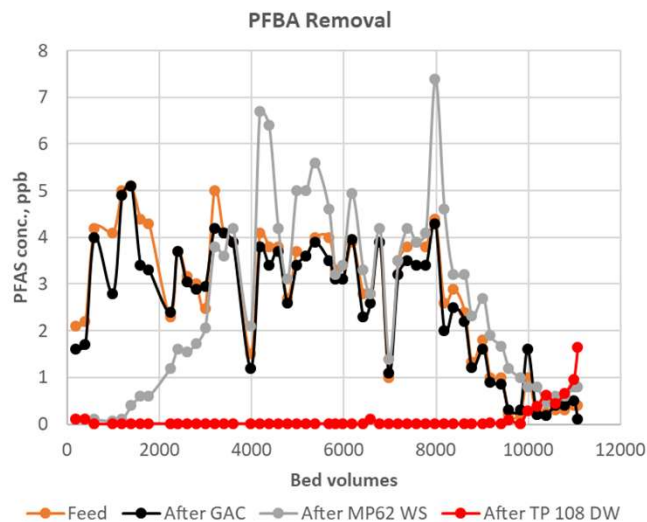


## PFHxA breakthrough curves generated USA



# PFAS treatment in a fire-fighting facility

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



## 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<sup>3</sup>/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

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

# LANXESS has the right products and technical expertise for every application



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





# Disclaimer



**Health and Safety Information:** Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the LANXESS products mentioned in this publication. For materials mentioned which are not LANXESS products, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be followed. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets, product information and product labels. Consult your LANXESS representative in Germany or contact the Regulatory Affairs and Product Safety Department of LANXESS Deutschland GmbH or - for business in the USA - the LANXESS Corporation Product Safety and Regulatory Affairs Department in Pittsburgh, PA, USA.

**Regulatory Compliance Information:** Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, BfR, NSF, USDA, and CPSC. If you have any questions on the regulatory status of these products, contact – for business in the USA- , the LANXESS Corporation Regulatory Affairs and Product Safety Department in Pittsburgh, PA, USA or for business outside US the Regulatory Affairs and Product Safety Department of LANXESS Deutschland GmbH in Germany.

The manner, in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations are beyond our control. Therefore, it is imperative that you test our products, technical assistance and information to determine to your own satisfaction whether they are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by us. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information.

Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with patents covering any material or its use. No license is implied or in fact granted under the claims of any patent.

# LANXESS

A thick red horizontal bar is positioned below the 'LAN' portion of the 'LANXESS' logo.

Energizing Chemistry