Ahlstrom-Munksjö – Global leader in fiber-based solutions

- Fibers are at the core of what we do and the common denominator for our products and solutions
- Natural fibers represent 94% of our total fiber use
- We offer custom made specialized fiber based materials
- Our value proposition is based on innovation, quality and service
- Our offering contributes to a more sustainable everyday life by providing renewable materials that are alternatives to non-renewables, and solutions that make the end product more sustainable



Key facts

- Global network of sales offices and 45 plants and converting sites in 14 countries, approximately 8,000 employees
- More than 7,000 customers in over 100 countries
- Pro forma 2018 net sales of approximately EUR 3 billion
- Shares listed on Nasdaq Helsinki and Stockholm
- Head office in Helsinki

Content

- Ahlstrom–Munksjö in a nutshell
- In-house analytical technical capabilities
- Disruptor® Overview
- Disruptor® Performance
  - ✓ Biologic retention
  - ✓ Chlorine retention
  - ✓ Metal/heavy-metal retention
  - ✓ PFC retention
  - ✓ Trace pharmaceuticals retention
  - ✓ Disruptor® for RO systems



Scanning Electron Microscopy (SEM)



Equipment: Phenom Pro X

Principle:

Electron microscopes use electrons for imaging, in a similar way that light microscopes use visible light. SEMs use a specific set of coils to scan the beam in a raster-like pattern and use the electrons that are reflected or knocked off the near-surface region of a sample to form an image. Since the wavelength of electrons is much smaller than the wavelength of light, the resolution of SEMs is superior to that of a light microscope.

Applications:

- Resolution < 10 nm
- EDX module for the determination of the chemical composition
- Ability to work in environmental conditions (atmospheric pressure)

ICP - AES

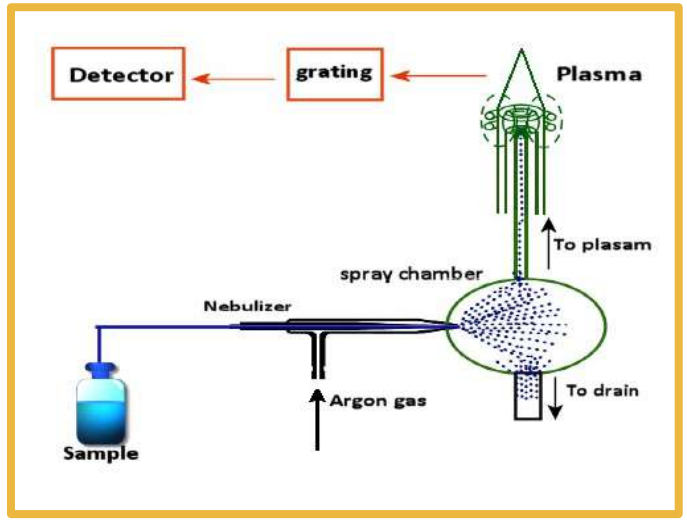
Equipment: Optima 2000 DV by *Perkin Elmer*

Principle:

Atomic technique used for detection of trace element.
Atomes are nebullized into an argon plasma in order to reach an excited state. To return to stable state, the atom emits light. The amount of emitted light is proportionnal to the concentration of the atom following Beer Lambert 's law.

Applications:

- Heavy metals analysis
- Detection limit down to ppb
- 30 analyses per hour



Elemental Analysis: ICP-OES Detection Limits (µg/ml)

Periodic Table of the Elements

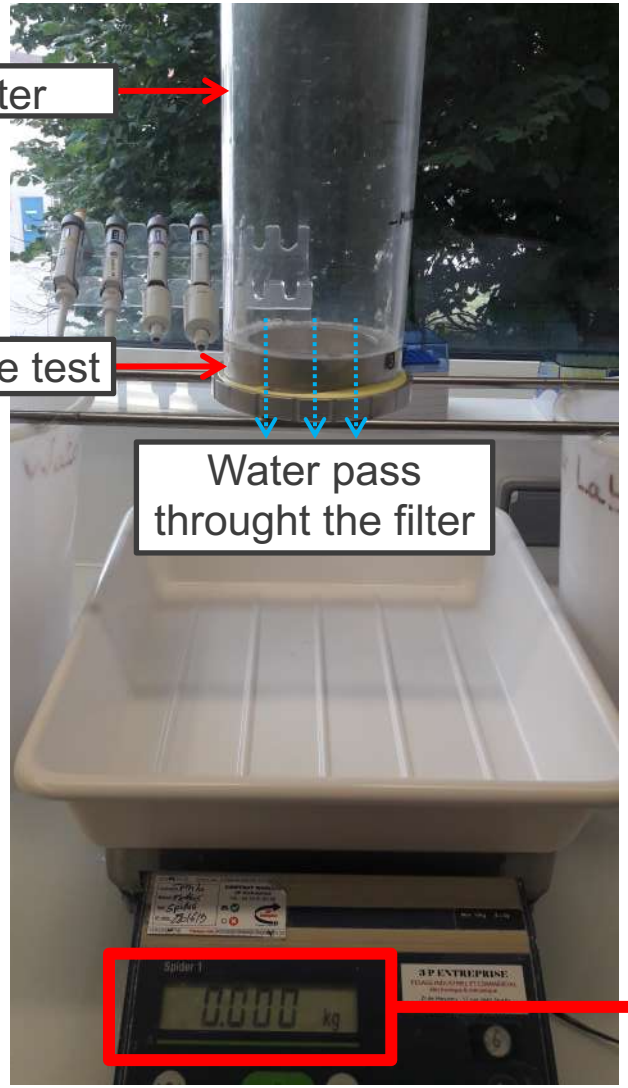
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt									
				Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
				Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

ICP-OES Detection Limits (in solution)

	Not Analyzed
	<0.005 ppm
	0.005-0.05 ppm
	> 0.05



Gravity filtration



Measurement of the weight versus time



Specifications

Filter diameter: 11.4cm
Filter area : 121 cm²

H_{water} for 3L : 24.8 cm
H_{water} for 2L : 16.5 cm
H_{water} for 1L : 8.2 cm

This test is set up to compare the gravity filters.

The aim is to compare the time needed for the filtration of 1L under a coloumn of water.

Bubble Point Measurement

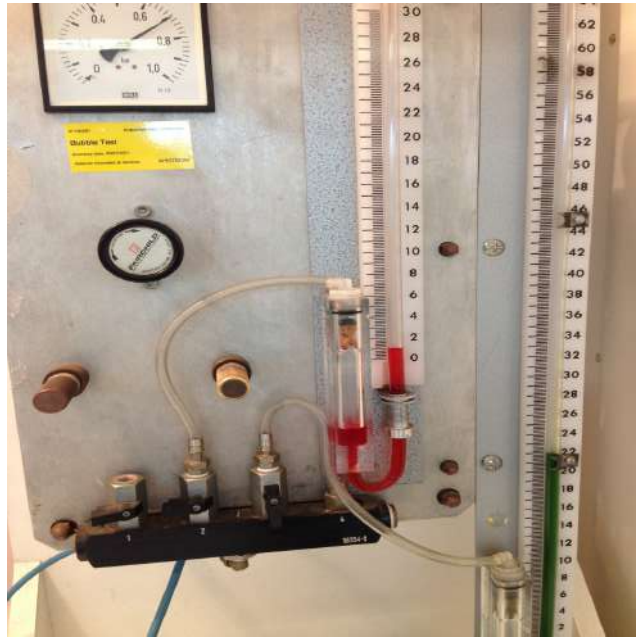
Equipment:
Home made manometer with control of low air pressure

Principle:

- Flat sheets or cartridges are dipped in Ethanol.
- A very low air pressure is applyed and the flow is increased slowly until the apparition of an air bubble.
- It is an easy way to control if there is defects on the seam or endcap of cartridges
- Based on **ISO 2942:2004** procedure

Applications:

- Bubble point of cartridges
- Pore size of flat sheets



Test bench for flat sheets



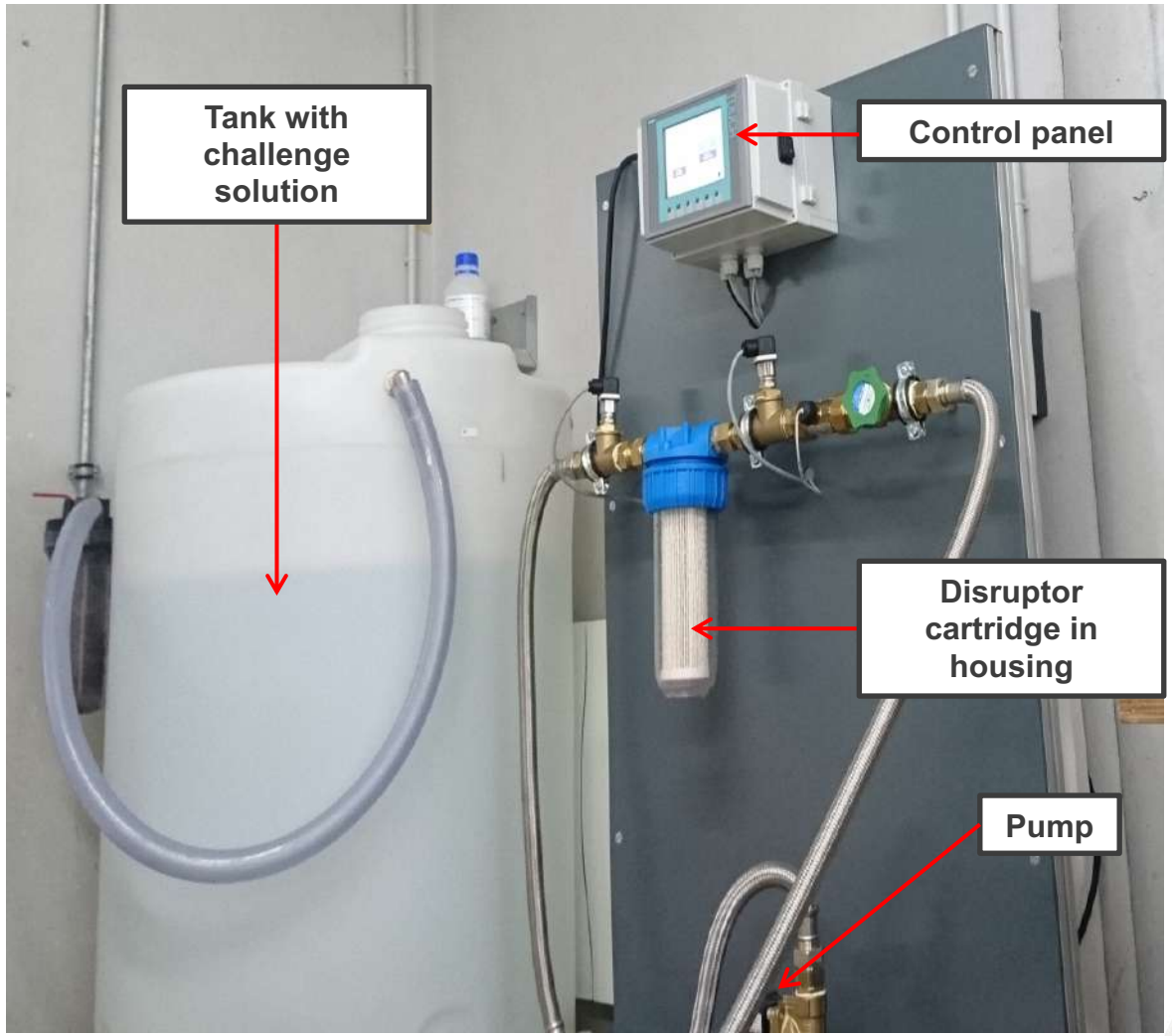
Test bench for cartridges

Test Bench for Cartridges

Equipment:
Test bench equipped with Siemens SIMATIC S7-1200 and LOWARA pump

Principle:

- Filtration of challenge water solution such as tap water, deionized water, water model, water with contaminants, erythosin solution
- Use of Cartridges (10 inch, 20 inch…)
- Control of the flow rate and measure/record the pressure drop
- Maximum flow rate 4.2 m^3/h



Gruenbeck test bench for cartridges

Test bench for Retention study

Initial solution:

- Tap water from Pont Evêque (*Conductivity 590 µS/cm, Temperature 20°C, TDS 310 mg/L, pH 7.4*)
- Agitation
- Peristaltic pump
- Flat sheet samples
- Flow rate: 1 gpm
- Lead initial concentration: 150 ppb
- Chlorine initial concentration: 2 ppm

Filter holder diameter (mm)	Specific filtration area (cm^2)	1 gpm/ft^2
89 (Lead)	46.6	190 ml/min
51	13	53 ml/min
25 (Chlorine)	3.9	16 ml/min

Elements titration:

- Analysis by **ICP-AES** for **Lead**. The limit of Quantification of ICP-AES (LQ) is **5 µg/L.** The challenge solution and the filtrates were treated according to the **DIN EN ISO 11885** norm by treating the sample with 2 % nitric acid (65%)
- Analysis by spectrophotometry using kit test reagents from Hach for **Chlorine**. Concentration range between 0 and 2 mg/L.



Filtration set up for Flat sheet testing

Test Bench for Bacteria Retention

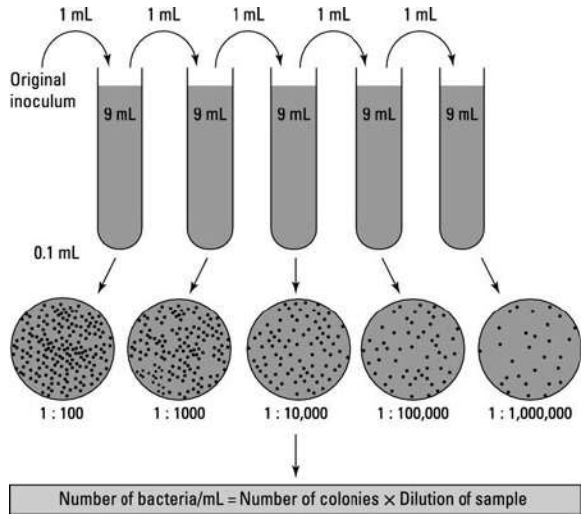


Classical testing method

Plate counting on Agar plate is currently the most use method for bacteria counting. Although this method is cheap, it requires time and some expertise in microbiology to be applied.

The method consists in making successive dilutions from the sample to analyze, and spread them on plates in order to be counted after a 24h incubation.

Because of the low range of use of plate counting and not knowing the concentration, many dilutions and many plating are necessary. This implies the use of a lot of consumables and a significant amount of time.

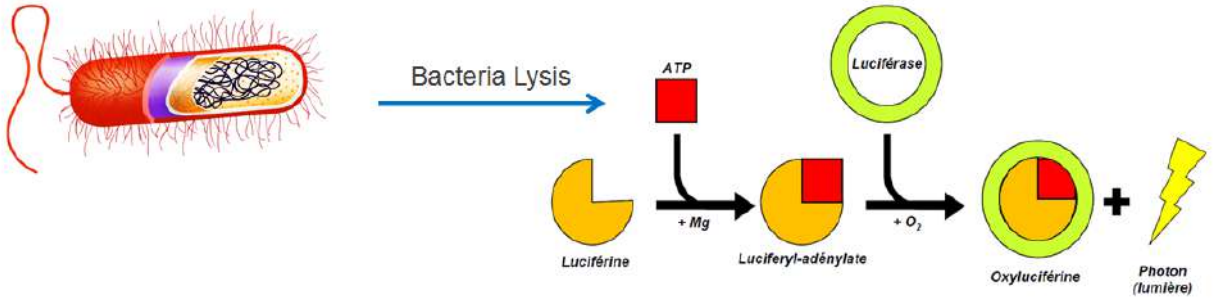


What about bacteria retention Capacity testing?

The Principle of ATPmetry

Adenosine triphosphate (ATP) is the major intermediary energy required in most of cellular metabolism reactions. Every living cell produces and consumes ATP it is assumed that all traces of ATP are the witness of a trace of life. In water, quantify ATP returns to quantify total microorganisms.

ATP is easily obtained by bacteria lysis. ATP reaction with luciferin and luciferase allows the formation of a complex and the release of energy in the form of light. The reaction and the reading of the light emitted with a luminometer are almost instantaneous.



Benefits

- **Time saving:** Plate Count Agar (PCA) needs incubation time of 24h while ATPmetry gives results in minutes making it easier to accurately re-produce the same test conditions (challenge solution)
- **Cost savings:** External testing of full capacity comes with a cost of more than 5000$. Thanks to this method, a single test (not counting the manpower) is about 150$.
- **No specifics skills** are required for this method. Moreover no dilution are needed decreasing the potential handling errors.

Ahlstrom-Munksjö has a strong dedication to innovation covering a wide range of functionalities and end applications







Micro-biology know-how

Chemistry
- Analytical
- Polymers
- Organic

Physical chemistry
- Barrier properties
- Separation
- Filtration
- Diffusion
- Rheology

Materials
- Natural fibers
- Man-made fibers
- Binders
- Fillers
- Polymers
- Bio-Polymers

Life Science & Sustainability
- Biochemistry
- Microbiology
- Water purification
- Ecodesign

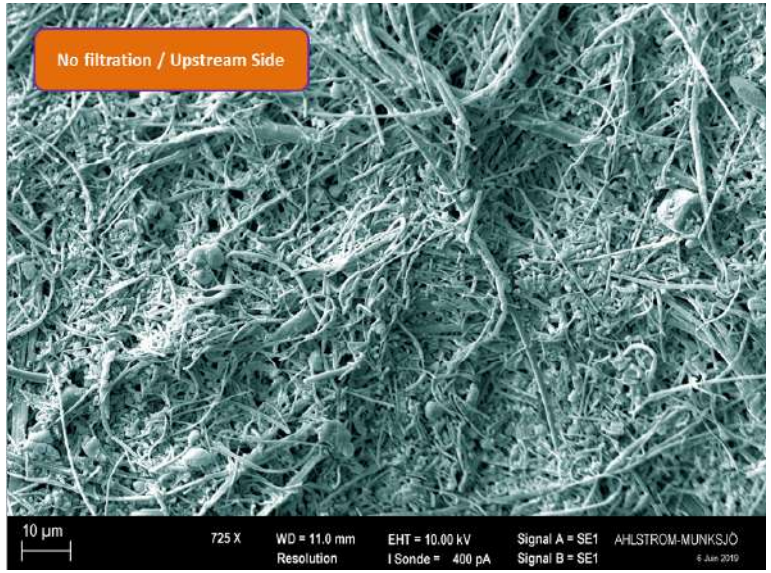
Pilots & Process
- Wet laid (paper & Nonwoven)
- Polymer processing Surface Coating
- Impregnation
- Web functionalization

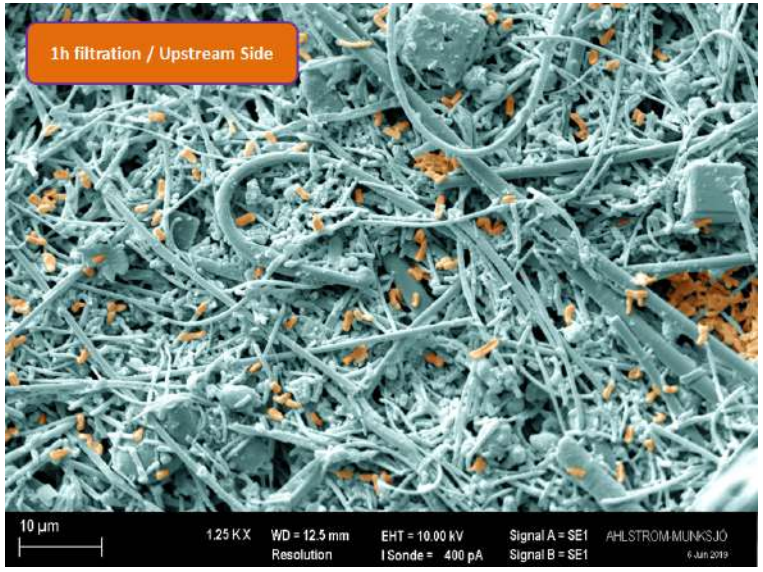
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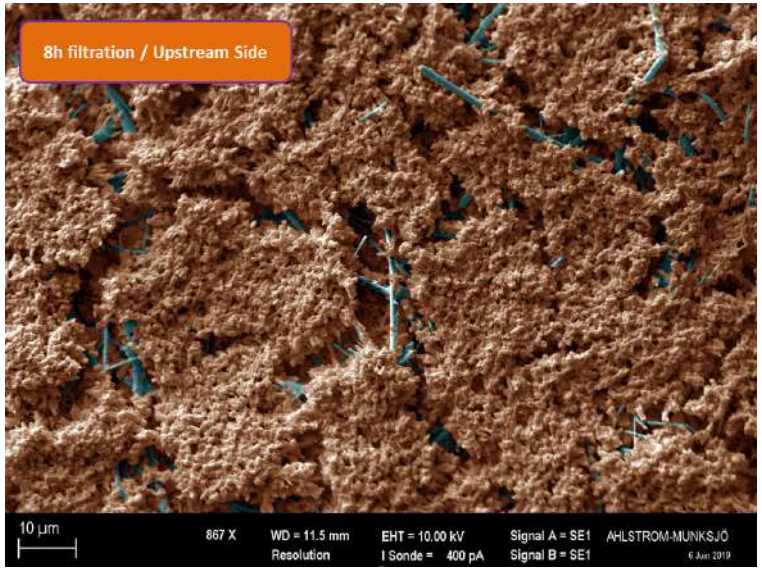
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Disruptor® is a breakthrough technology and not directly comparable to any other water filtration media in the current market place



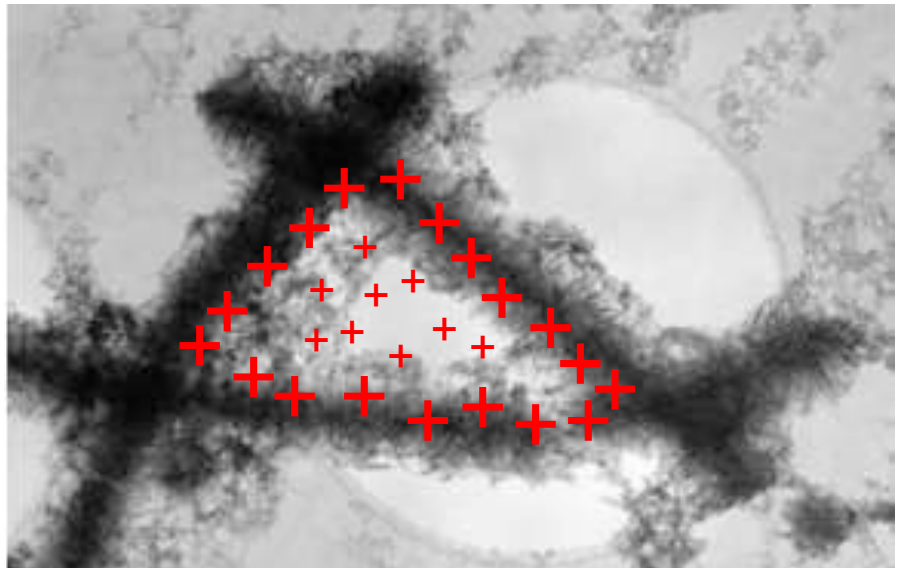


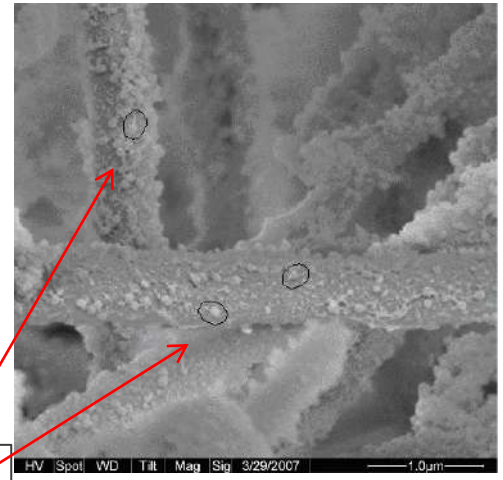


Disruptor® removes hundreds of billions of pathogens per m^2 of media @ 99,9999% efficiency!!

What is Disruptor®?

- Disruptor® is a breakthrough technology for the **more demanding** water purification needs.
- Not directly comparable to any other water purification media currently in the market, Disruptor® is an **electro-adsorptive technology**: due to its crystal structure, the mineral creates a natural, strong positive charge which attracts the negative charge present on most submicron contaminants.
- When exposed to water having a **pH between 5 – 9** a charge potential is generated by the natural crystal structure of the fibers overlapping further into the fiber pore structure.
- Since Disruptor® is an electro-positive wet-laid nonwoven with a pore size around 1.2-1.5 microns it captures very small diameter substances and pathogens, but in addition also removes larger particles **mechanically**.





Bacterial cells: typically 1-10 micron
in length & 0,2-1 ,0 micron in width

Viruses: typically 0,004 – 0,1 micron in size

Cysts: typically 2 – 50 micron in diameter

Primary Operational Parameters for Disruptor

Every POE/POU application is different and the following operational parameters for are only serving as a generic guideline:

- Optimum flow range: 1- 3 gallons/min/ft^2 (40 – 120 liter/min/m^2)
- Effective pH range: *5* – 9
- Temperature range: 4 - 57 C (39 – 135 F). Per NSF 42 testing temperature set at 17 – 23 C (63 – 73 F)
- Maximum pressure: 70 psi (4,8 bar)
- Filter life: Disruptor® removes billions of pathogens per m^2 but the effective filter life depends on the water quality and conditions at each specific site
- Certification: All Disruptor® products are NSF 42 compliant

Certification landscape

- **ISO Certification**
- Total Production, Management, Environment, Quality, and Safety Systems

- **NSF/ANSI 42 Certification**
- NSF and WQA are two independent and very similar certification organizations testing, auditing, and certifying products and water systems
- NSF considered globally the stronger brand
- Ahlstrom-Munksjö used to carry both but, decided in 2018 to abandon WQA and continue with only NSF



OFFICIAL LISTING

NSF certifies that the products appearing on this Listing conform to the requirements of NSF/ANSI 42 - Drinking Water Treatment Units - Aesthetic Effects

This is the Official Listing recorded on November 2, 2018.

Ahlstrom Filtration LLC
122 West Butler Street
Mount Holly Springs, PA 17065
717 486-3438

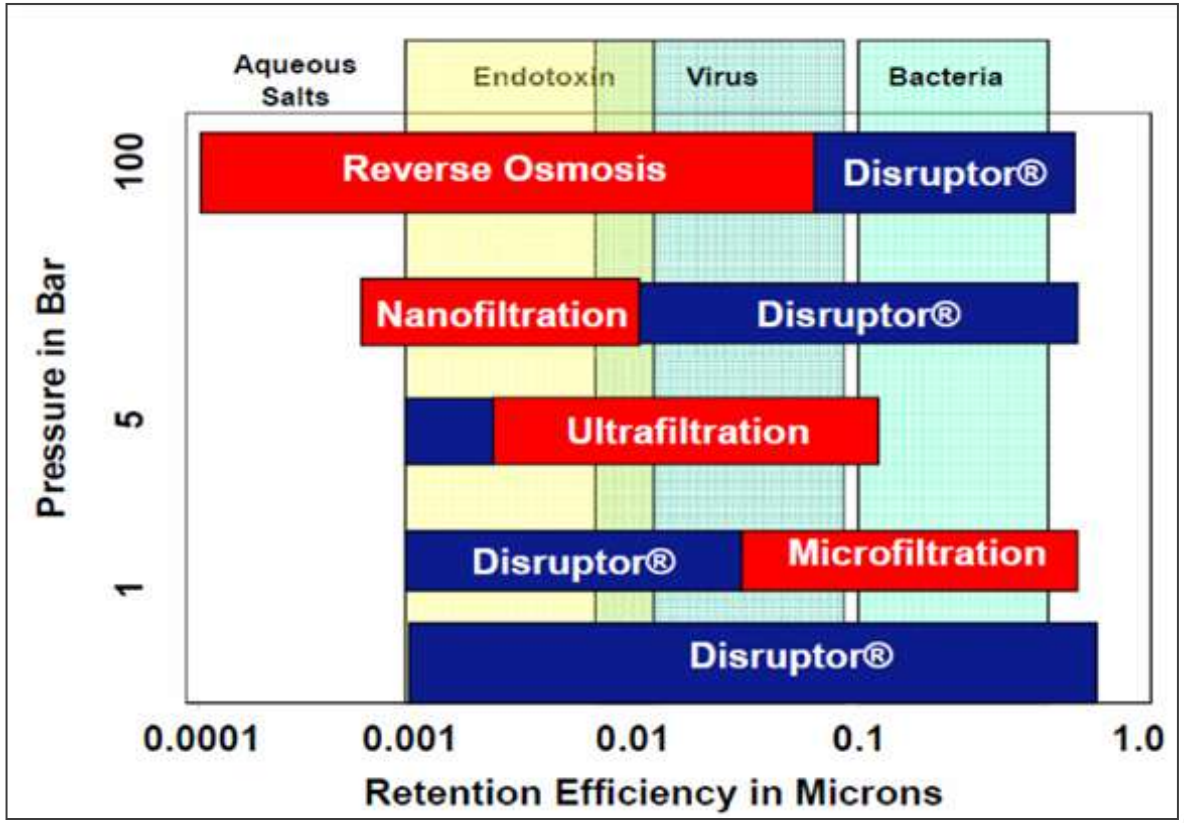
Facility: Mount Holly Springs, PA

COMPONENTS: Filter Media[1]

Grade 4616	Grade 5281	Grade 5282	Grade 5283	Grade 5283A
Grade 5283N	Grade 5284	Grade 5287	Grade 5288	Grade 5289
Grade 5293	Grade 5294	Grade 5297	Grade 5298	Grade 5299
Grade 5300	Grade 5301	Grade 5302	Grade 5303	

How can Disruptor® be used?

- Due to the open media structure Disruptor® can be used in a very wide range of end uses covering both **pressurized** water purification systems as well as **gravity flow** applications.
- Disruptor® can compete as a **stand alone** alternative to polymeric membranes or used **in combination** with other water purification technologies.
- In addition to outstanding pathogen performance products available also with special functionalities such as **chlorine** removal, **heat-sealing**, and **antimicrobial treatment** for preventing bacteria build-up.
- The removal of selected particulate **metals** also possible in given pH ranges.
- Disruptor® media is **easy to convert** and can be made into virtually any size pleated filter cartridge.



Where can Disruptor® be used? (cont.)

Applicable both for point-of-entry (POE) and point-of-use (POU) applications:

- In a single or multi-layer Disruptor® stand-alone format for biological removal (personal & residential)
- In a single or multi-layer Disruptor® stand-alone format for biological removal and chlorine removal (personal & residential)
- In combination with CTO (Carbon Blocks) for biological removal, chlorine, and/or heavy-metal removal with e.g. ion exchange chemistry (personal & residential)
- Before RO system for reducing RO membrane fouling (residential & commercial)
- After RO system for biological removal and improved water taste (residential & commercial)
- Gravity applications such as countertop dispensers, rain water treatment, roof top filters, etc. (personal & residential)








Where can Disruptor® be used? (cont.)

Filtration Technology Positioning

Water Remediation Technologies - Residential, Commercial, Industrial, Municipal, Desalination								
	Disruptor® PAC Technology	RO	NF	UF	MF	Particulate Catridges	Carbon Block	Ultra Violet
Contaminants								
Dissolved Salts		x						
Endotoxin	x	x	x	x	x	x		
Virus	x	x	x					x
Bacteria	x	x	x	x	x	x	x	x
Cysts	x	x	x	x	x	x	x	x
Polysaccharides (TEP)	x	x	x	x	x			
Colloids	x	x	x	x				
Particulates	x	x	x	x	x	x	x	
Chemical Reduction	x	x					x	x
Trace Pharmaceuticals	x	x					x	x

Membrane definition: Reverse Osmosis=RO; Nanofiltration=NF; Ultrafiltratio=UF; Microfiltration=MF.

Disruptor® - Standard Product Portfolio

Properties	5283	5288	5289	5293
Grade type	White	White	PAC for Chlorine removal	PAC for Chlorine removal
Special treatment	Heat-sealable	Heat sealable Antimicrobial	Heat-sealable Antimicrobial	Heat-sealable Antimicrobial
Basis weight – gsm	318	313	313	313
Thickness – mm	0,99	0,95	0,95	0,95
MFP – micron	1,2	1,2	1,4	1,55
Rapidity – mls/min	9,0	9,0	9,0	9,0
Biological removal Initial LRV: RT, MS2, Cyst	Log 6 / Log 4 / Log 3,5	Log 6 / Log 4 / Log 3,5	Log 6 / Log 4 / Log 3,5	Log 6 / Log 4 / Log 3,5

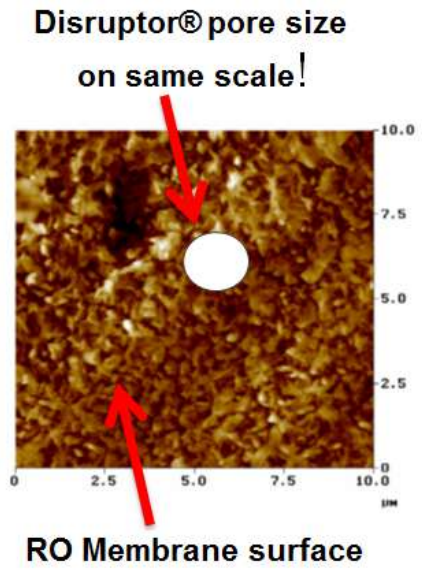
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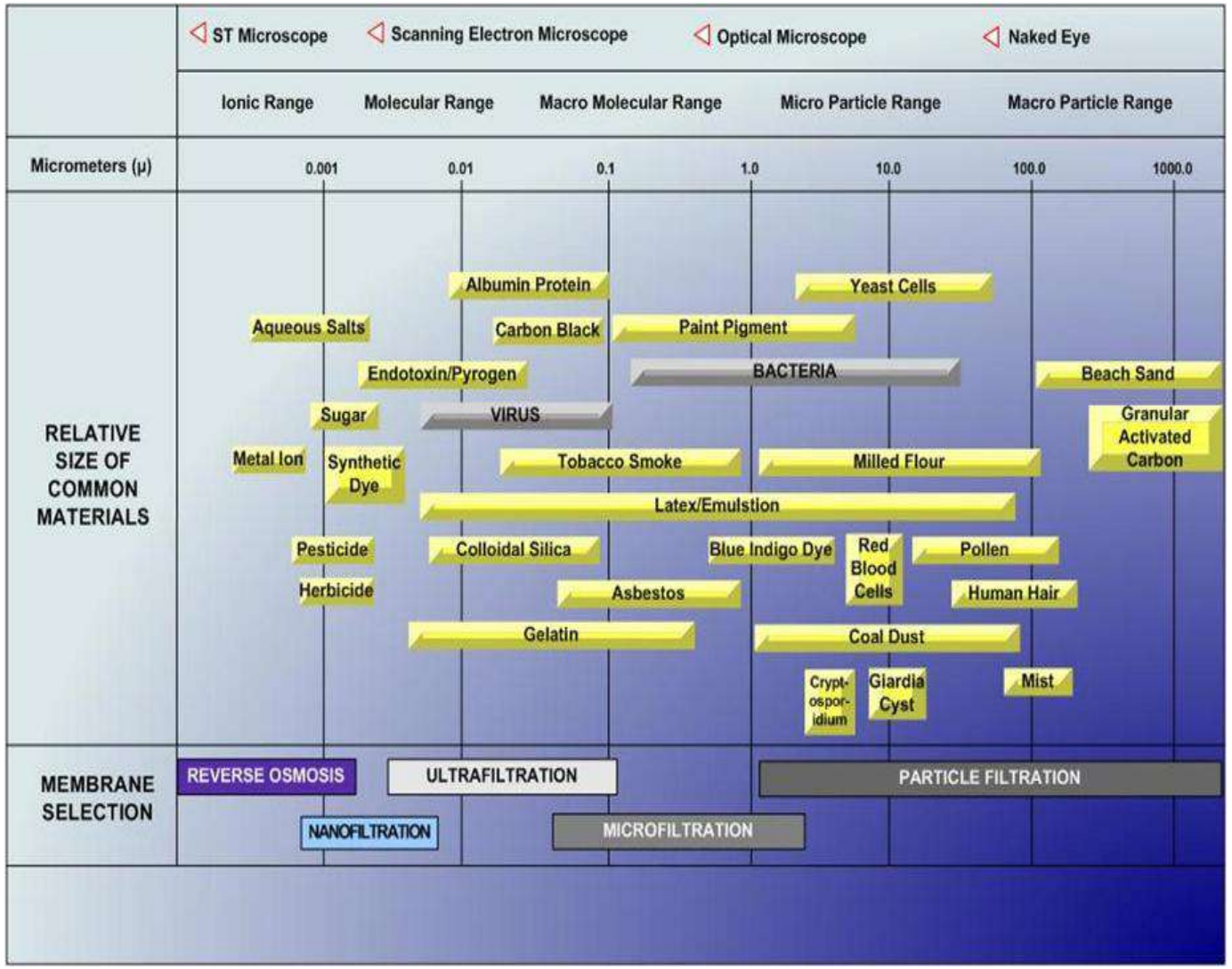
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Biological testing vs. pathogen and contamination types

- Reduction of virus typically requires the use of ultrafiltration or reverse osmosis membranes
- Disruptor® technology reduces virus, bacteria and endotoxin with high flow and low pressure drop as compared to polymeric membranes





Ahlstrom-Munksjö quality testing of initial bacteria (RT), virus (MS2), and cyst (test method: TM-120)

Bacteria

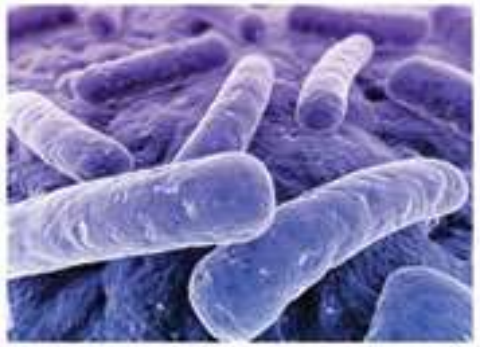
- *Raoultella terrigena*
- Influent concentration of 10^5 or 10^6 per ml
- Required reduction 99.9999% or **6 log**

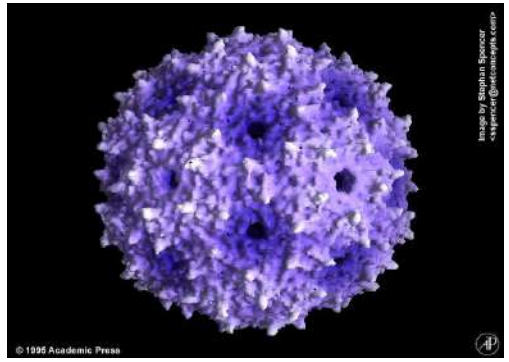
Virus

- MS2 Bacteriophage
- Influent concentration of 10^5 or 10^6 per ml
- Required reduction 99.99% or **4 log**

Cyst

- 3 micron bead surrogate
- Influent concentration of 10^5 or 10^6 ml
- Required reduction 99.95% or **3.5 log**







In comparison: Ganges River in India carries a total coliform concentration in the 1 x 10^6/ml range

E coli capacity for 5283

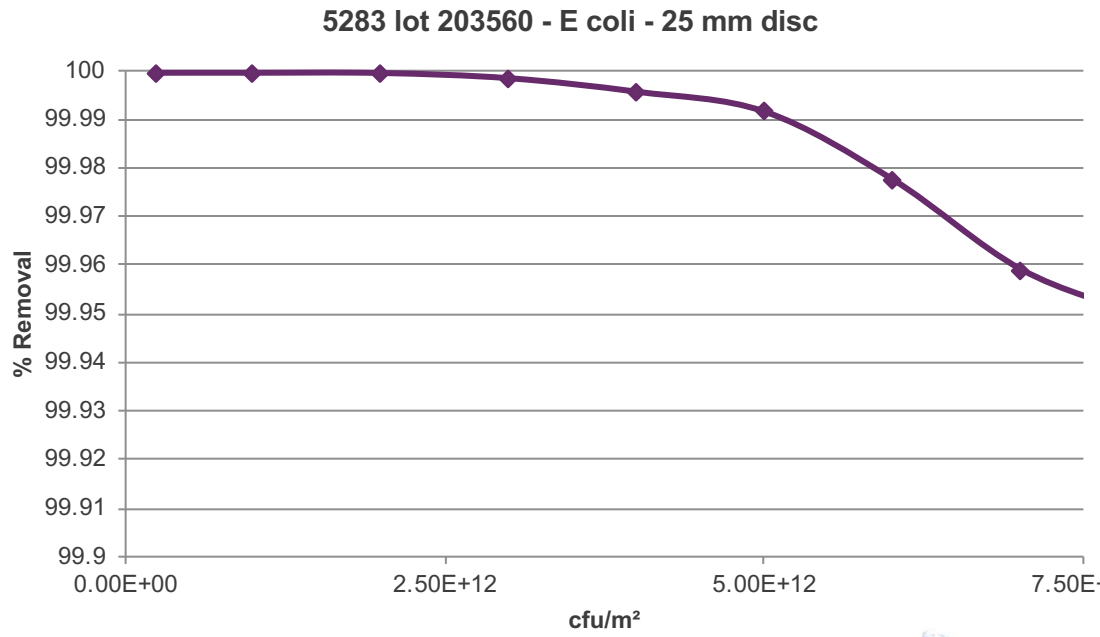
5283:

Grade type: White
Special treatment: Heat-sealable

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	36000 L/m²	7200 L/m²	3600 L/m²	1800 L/m²	900 L/m²
	log 4	60000 L/m²	12000 L/m²	6000 L/m²	3000 L/m²	1500 L/m²
	log 3	100000 L/m²	20000 L/m²	10000 L/m²	5000 L/m²	2500 L/m²



Example of E coli retention on 5283

E coli capacity for 5283N

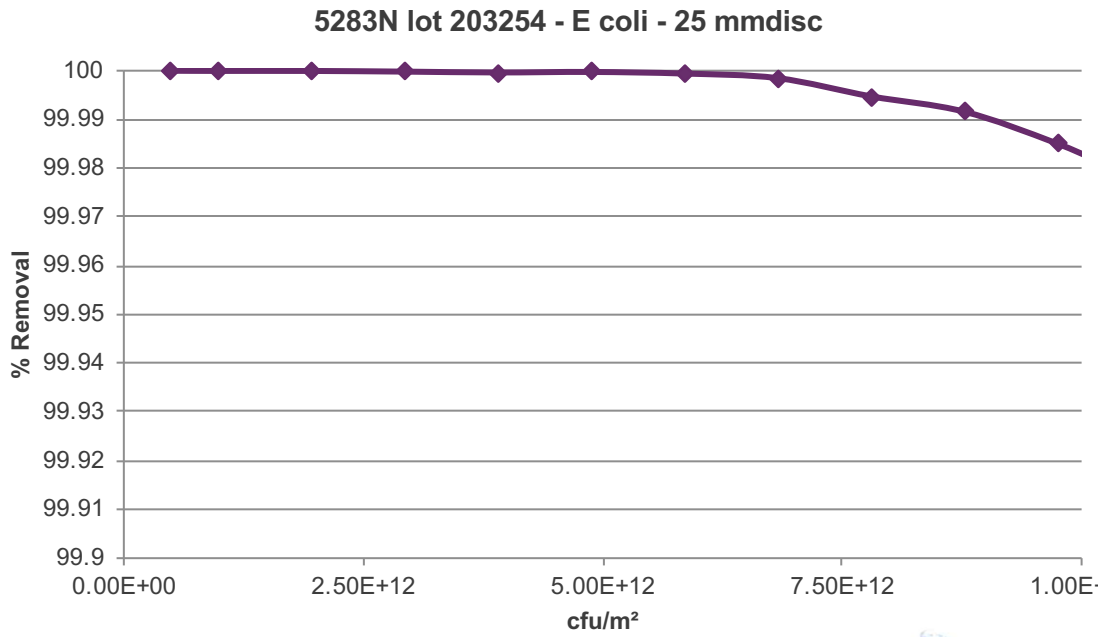
5283N:

Grade type: White
Special treatment: Heat-sealable
Netting Lamination

		Challenge: [E Coli]$_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	66000 L/m²	13200 L/m²	6600 L/m²	3300 L/m²	1650 L/m²
	log 4	92000 L/m²	18400 L/m²	9200 L/m²	4600 L/m²	2300 L/m²
	log 3	172000 L/m²	34400 L/m²	17200 L/m²	8600 L/m²	4300 L/m²

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry



Example of E coli retention on 5283N

E coli capacity for 5284

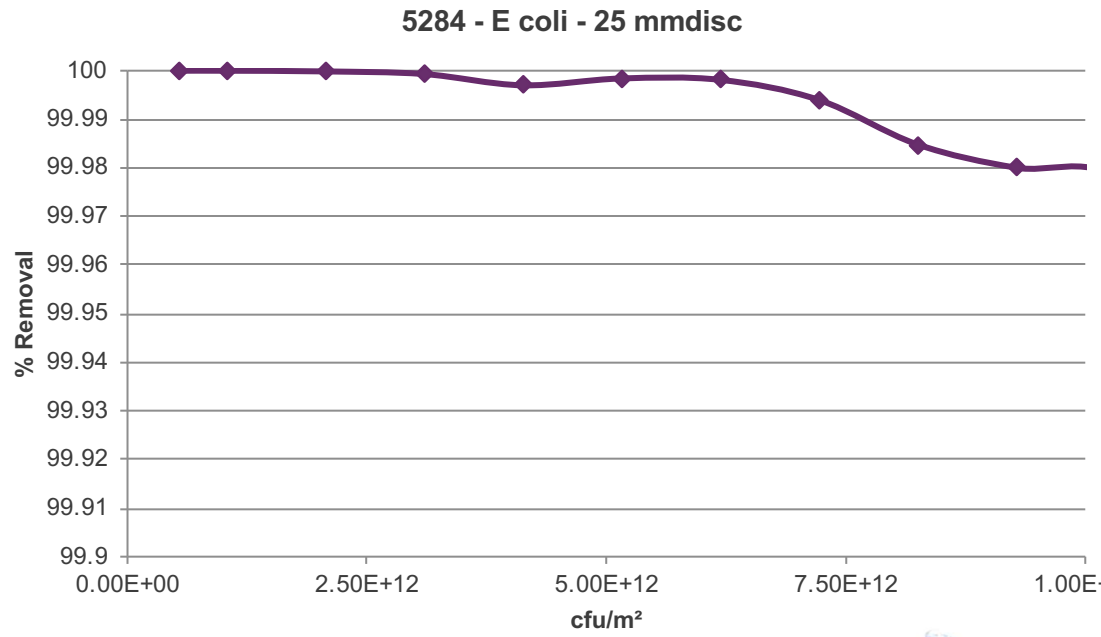
5284:

Grade type: Carbon
Special treatment: Heat-sealable

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	36000 L/m²	7200 L/m²	3600 L/m²	1800 L/m²	900 L/m²
	log 4	70000 L/m²	14000 L/m²	7000 L/m²	3500 L/m²	1750 L/m²
	log 3	160000 L/m²	32000 L/m²	16000 L/m²	8000 L/m²	4000 L/m²



Example of E coli retention on 5284

E coli capacity for 5289

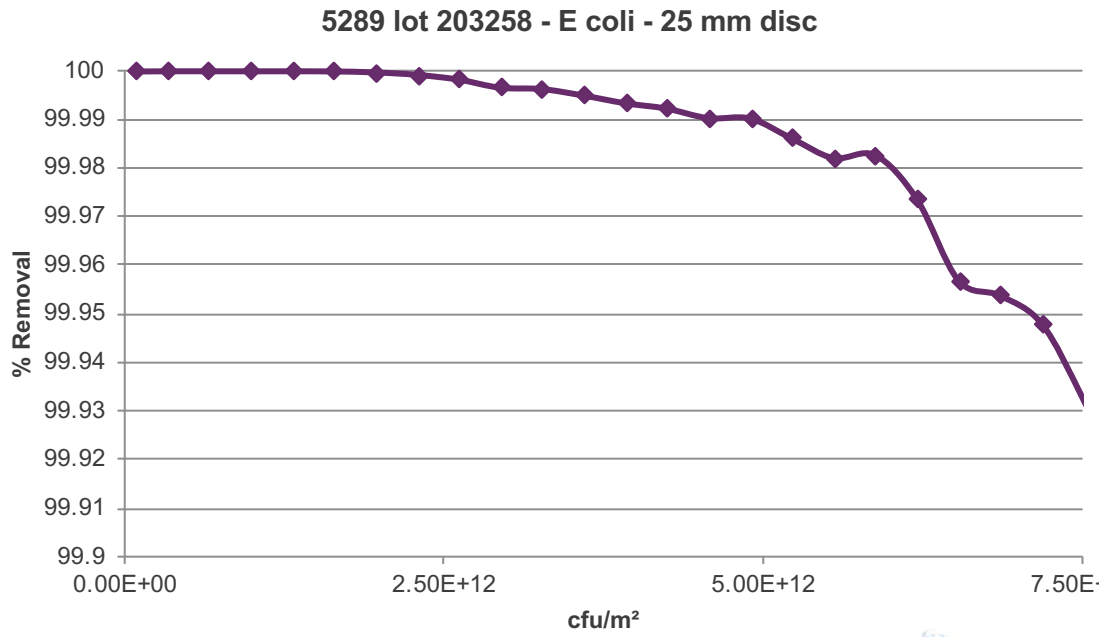
5289:

Grade type: Carbon
Special treatment: Heat-sealable
Silver treated

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	18000 L/m²	3600 L/m²	1800 L/m²	900 L/m²	450 L/m²
	log 4	32000 L/m²	6400 L/m²	3200 L/m²	1600 L/m²	800 L/m²
	log 3	56000 L/m²	11200 L/m²	5600 L/m²	2800 L/m²	1400 L/m²



Example of E coli retention on 5289

E coli capacity for 5293

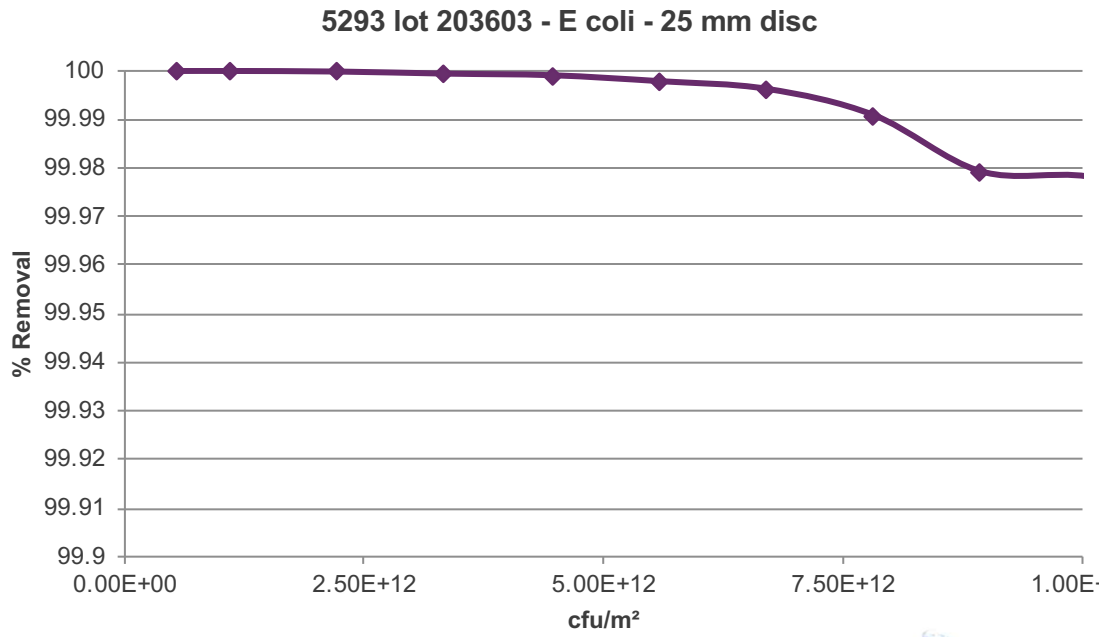
5293:

Grade type: Carbon
Special treatment: Heat-sealable
Silver treated

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	40000 L/m²	8000 L/m²	4000 L/m²	2000 L/m²	1000 L/m²
	log 4	64000 L/m²	12800 L/m²	6400 L/m²	3200 L/m²	1600 L/m²
	log 3	200000 L/m²	40000 L/m²	20000 L/m²	10000 L/m²	5000 L/m²



Example of E coli retention on 5293

E coli capacity for 4616

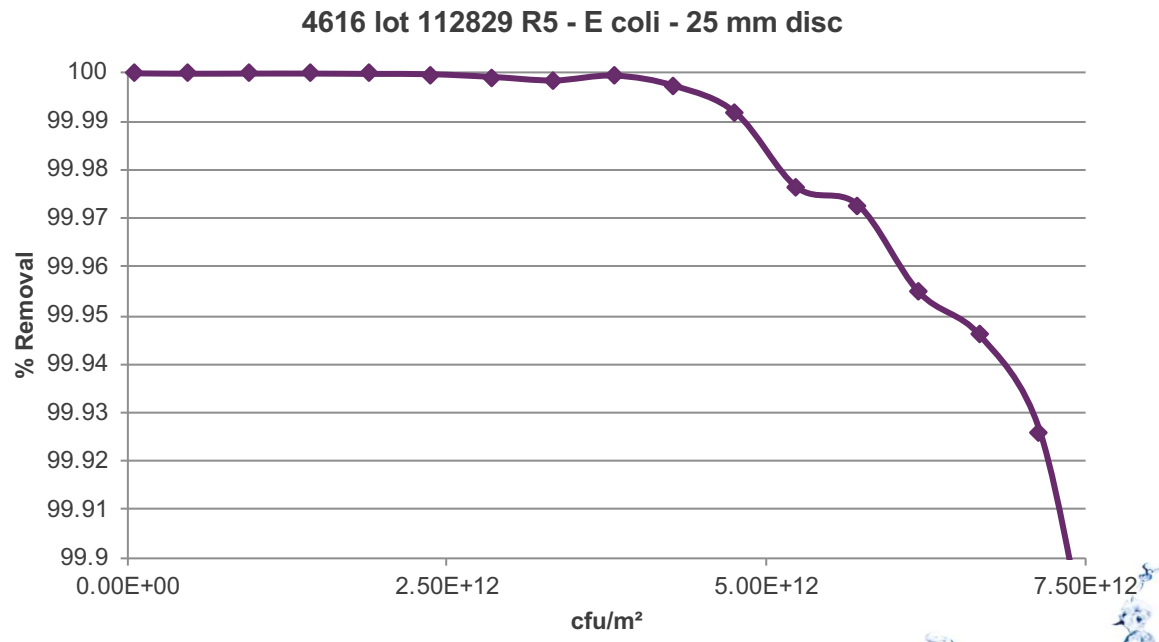
4616:

Grade type: White
Special treatment: Unlaminated
Glass-free

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	**5.00E+05**	**1.00E+06**	**2.00E+06**	**4.00E+06**
Retention (log)	**log 5**	36000 L/m²	7200 L/m²	3600 L/m²	1800 L/m²	900 L/m²
	log 4	52000 L/m²	10400 L/m²	5200 L/m²	2600 L/m²	1300 L/m²
	log 3	72000 L/m²	14400 L/m²	7200 L/m²	3600 L/m²	1800 L/m²



Example of E coli retention on 4616

E coli capacity for 5297

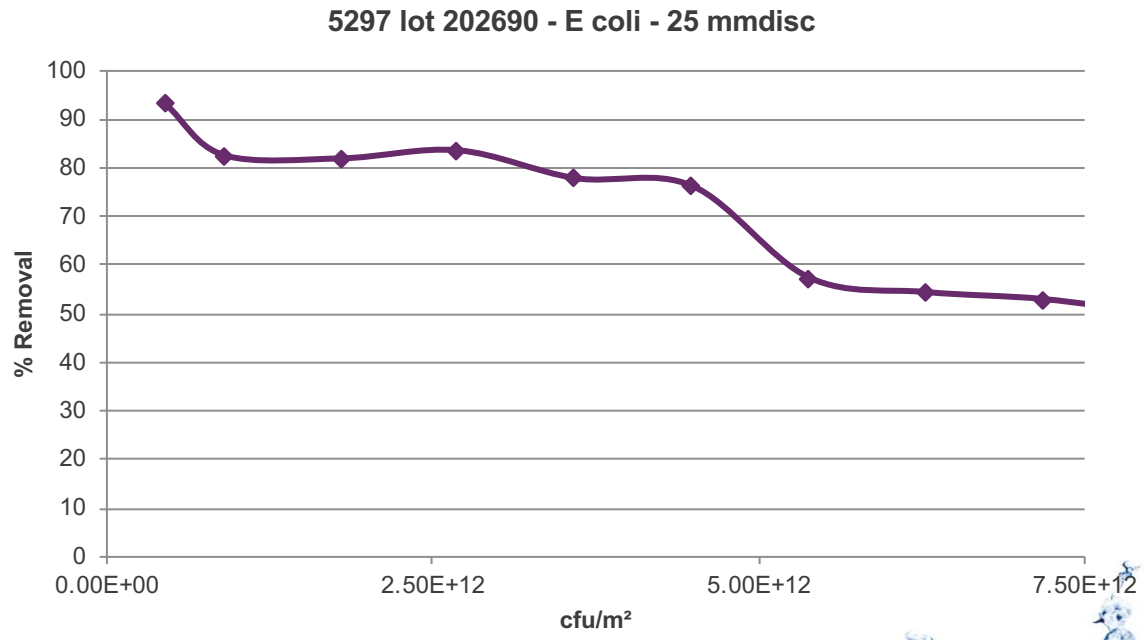
5297:

Grade type: Prefilter - White
Special treatment: Heat-sealable

Testing conditions:

Internal Protocol used: TM 140
Bacteria: E Coli
Water: Ringer
pH: 7.75 ± 0.25
Filter holder: 25 mm
Flow: 1 gpm
Temperature: 22°C ± 1°C
Soaking: few seconds with DI water
Analysis: ATP metry

		Challenge: $[E\ Coli]_i$ in cfu/mL				
		1.00E+05	5.00E+05	1.00E+06	2.00E+06	4.00E+06
Retention (log)	log 5	NA	NA	NA	NA	NA
	log 4	NA	NA	NA	NA	NA
	log 3	NA	NA	NA	NA	NA



Example of E coli retention on 5297

Disruptor and Legionella Reduction

Premise Plumbing POE filters

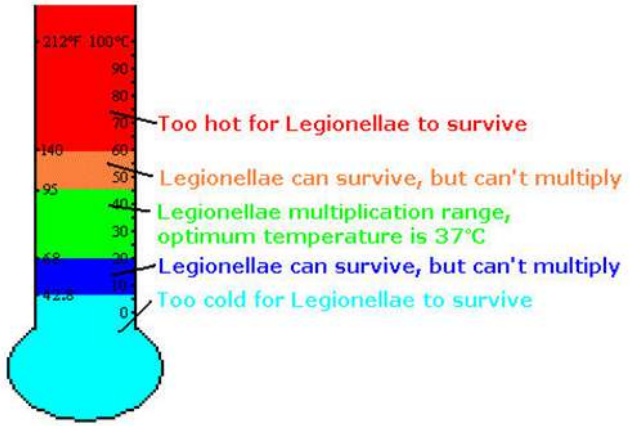
Cooling tower , cold water loops



Faucet Filter POU



Temperature range for legionella



- Disruptor can reduce bio scale buildup that is an environment for bacteria to live
- Iron that is a nutrient for the legionella bacteria causing growth
- Submicron particulate in pipe scale
- Legionella boil-outs typically at 160 F. (71 C) temperatures

Legionella Facts

- Legionella is the only growing waterborne illness in the developing world
- Cost of legionella estimated by the CDC annually is $434M
- In comparisons the cost of Cryptosporidiosis is $46M (CDC estimate)
- Disruptor can be used as a standalone technology or with other treatment technologies

Disruptor® Legionella Removal

Initial Legionella Removal

Disruptor Grades	Single Layer (LRV Removal)	Double Layer (LRV Removal)
5283 - White	4.6	4.7
5284 - Carbon	5.5	5.5
5288 - White	5.5	5.5
5289 - Carbon	5	5.5

- Only a slight benefit can be seen during initial biological testing with two layers of Disruptor, the main benefit of two layers is visible under capacity testing.
- Both white and Carbon Disruptor grades removes Legionella but more capacity tests needed for understanding of the overall performance

NSF P231 testing

Ten days performance testing:

- General Test Water 1 (GTW1): Tap water with low turbidity (w/tannic acid) and organic levels.
- General Test Water 3 (GTW3): Tap water with high turbidity (w/tannic acid) and organic levels.
- Challenge Water (CTW): Virus, Bacteria, and Cyst.
- LRV requirements: Bacteria = min. LRV 6, Virus = min. LRV 4, Cyst = min. LRV 3

General Test Water	GTW1	GTW3
Base	Tap Water	Tap Water
Total Chlorine	ND	ND
pH	6.5 - 8.5	9.0 ± .2
TOC	0.1 - 5.0 mg/L	not less than 10 mg/L
Turbidity	0.1 - 5 NTU	not less than 30 NTU
Temp	20° ± 5°C	4° ± 1°C
TDS	50 - 500 mg/L	1,500 mg/L ± 150 mg/L

Challenge Test Water	CTW
Bacteria	E. coli (EC)
Virus	Poliovirus
	Rotavirus
Cyst	Garida muris or Lamblia
	Surrogate

NSF P231 Test Results with GTW 1 & 3 challenge water

General Test Water 1 (GTW 1)

Filtration layers	Day 1 E.coli Removal	Day 3 E.coli Removal	Day 6 E.coli Removal	Day 7 E.coli Removal	Day 8 E.coli Removal	Day 9 E.coli Removal	Day 10 E.coli Removal
“New Formulation”	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV

Filtration layers	Day 1 Virus Removal	Day 3 Virus Removal	Day 6 Virus Removal	Day 7 Virus Removal	Day 8 Virus Removal	Day 9 Virus Removal	Day 10 Virus Removal
“New Formulation”	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV	6 LRV

Summary: **Disruptor formulation passes the full P231 test method with GTW 1 for virus and bacteria removal.**

General Test Water 1 & 3 (GTW 1 & 3)

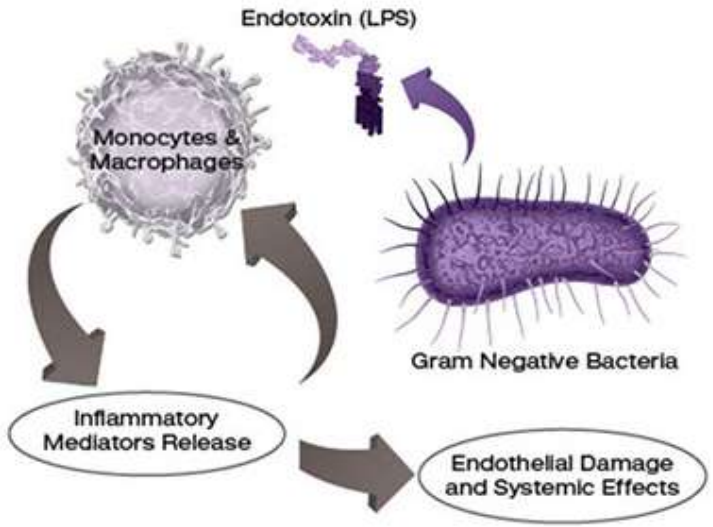
Filtration Layers	Day 1 E.coli Removal	Day 3 E.coli Removal	Day 6 E.coli Removal	Day 7 E.coli Removal
“New Formulation”	6 LRV	6 LRV	6 LRV	6 LRV

Filtration Layers	Day 1 MS2 Removal	Day 3 MS2 Removal	Day 6 MS2 Removal	Day 7 MS2 Removal
“New Formulation”	5 LRV	5 LRV	5 LRV	5 LRV

Summary: **Disruptor formulation did not have any E-Coli or virus breakthrough, but testing was stopped on day 7 due to reduced flow/filter plugging (passing P231 “by plugging”)**

Endotoxin or Lipopolysaccharide (LPS) removal

Lipopolysaccharides (LPS) are large molecules found in the outer membranes of pathogenic bacteria

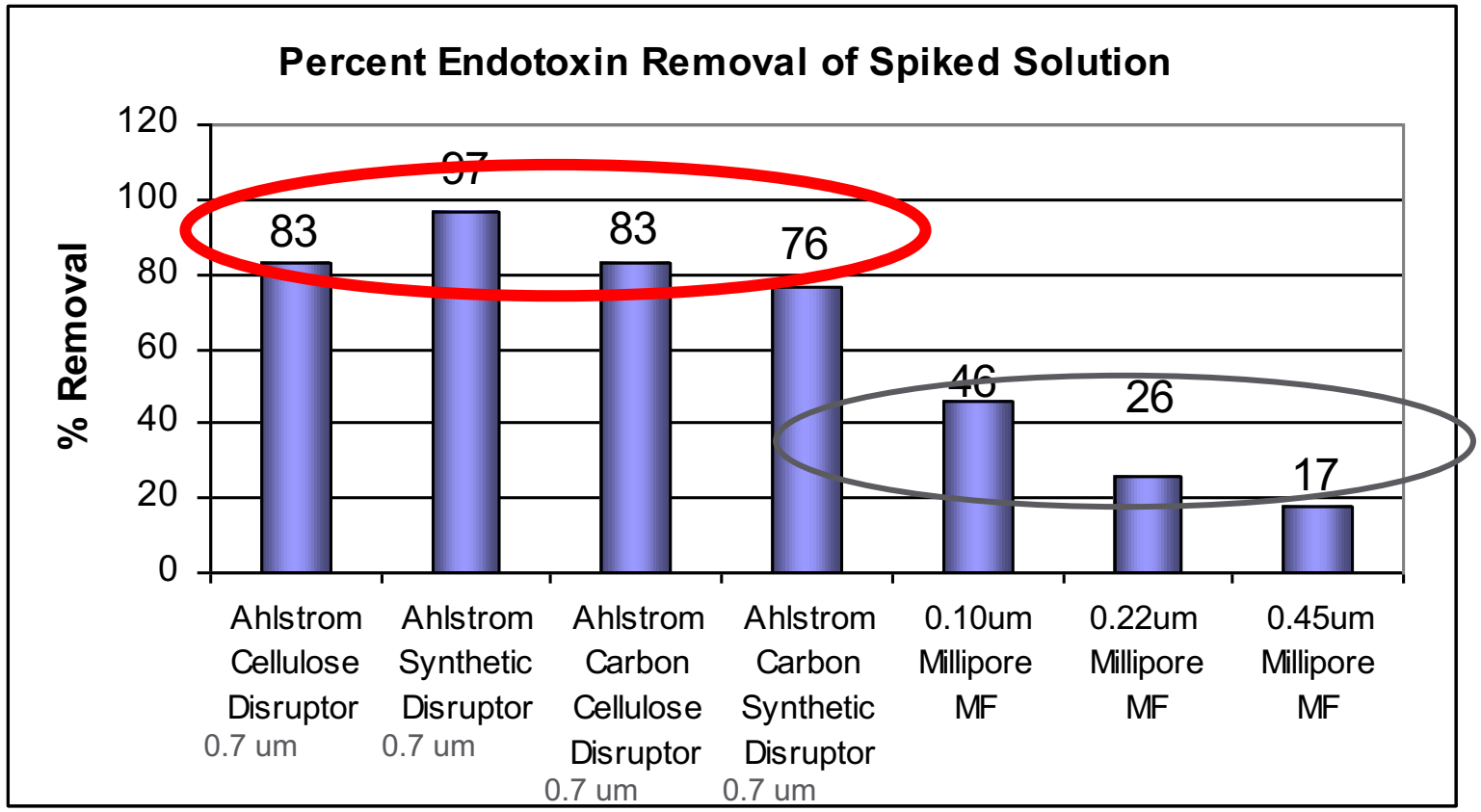


Can cause a severe immune response in people

- Elevated temperature
- Increased respiration
- Decreased blood pressure
- Endotoxin shocks **CAN BE FATAL**

Disruptor® media can reduce endotoxins!

Endotoxin – Percentage Removal vs. Membranes



Conclusions:

By the end of the study, each of the discs had been challenged with 3.85 x 10^6 EU. The Ahlstrom Disruptor versions removed a higher percentage of endotoxin than Millipore MF filters.

Despite the MF filters having a smaller pore size, the Disruptor removed more endotoxins. This study demonstrated that charge is more effective in retaining endotoxins than the pore size.

Endotoxin removal – 3rd party test results

SGS

Northview Laboratories

CERTIFICATE OF ANALYSIS

Client: HEATHER MOWERS
AHLSTROM FILTRATION LLC
122 WEST BUTLER ST
MOUNT HOLLY SPRINGS PA 17065

Assignment No.: 09A0800341
PO No.: 4500426032
Page: 1 of 1

Product Tested: Misc. Product
Date Received: 11-Jan-2008
Test/Method: **BET Kinetic- Medical Devices, USP <85>**
Specification: Sample Endotoxin Less Than Limit

LAL Kinetic Method: Chromogenic
Endotoxin Limit: 0.50 EU/mL
Extraction Method: Immersion

Sample No.	Sample Description	Number of Samples	Test Extraction	Extract Dilution	Result	Positive Product Control	PPC Limit Check	Status
09S08001586*	Heat Seal 9630	1	75 mL	1:10	<0.05 EU/mL	83.6 %	VALID	Pass

Evaluation

*09S08001586 This sample passes the test for bacterial endotoxins at 1/10 of the client specified endotoxin limit.
Validation (Inhibition/Enhancement Testing) declined by client.

Content

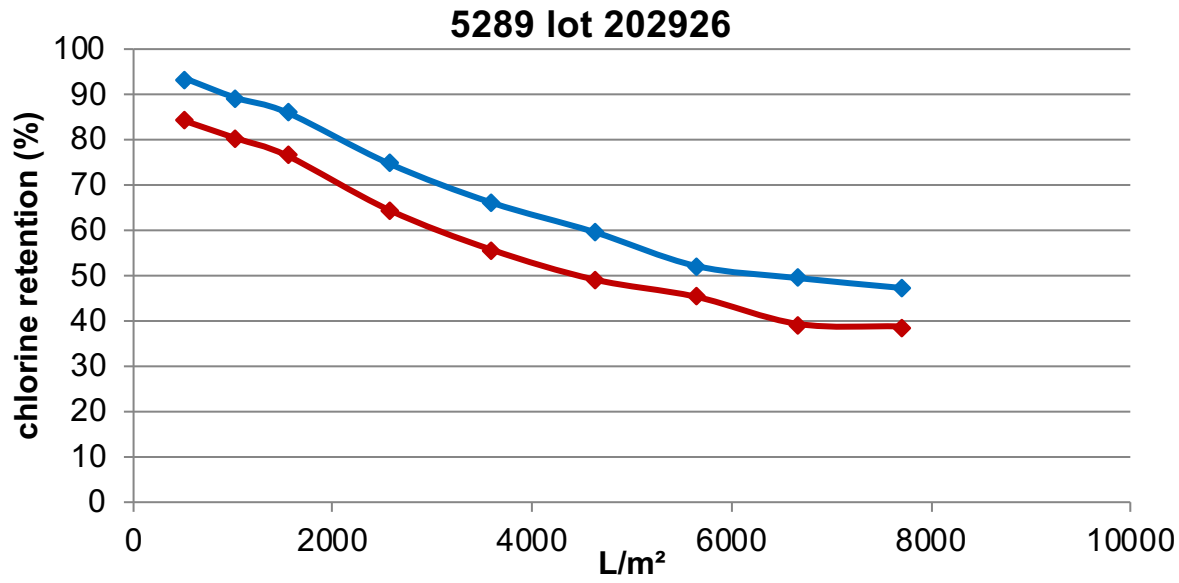
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- Disruptor® Performance
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  - ✓ Chlorine retention
  - ✓ Metal/heavy-metal retention
  - ✓ PFC retention
  - ✓ Trace pharmaceuticals retention
  - ✓ Disruptor® for RO systems



Chlorine Retention

Grade 5289

5289 is above 50% retention till 5 600 L/m²



Conditions:

- Tap water from Pont Eveque-PEV

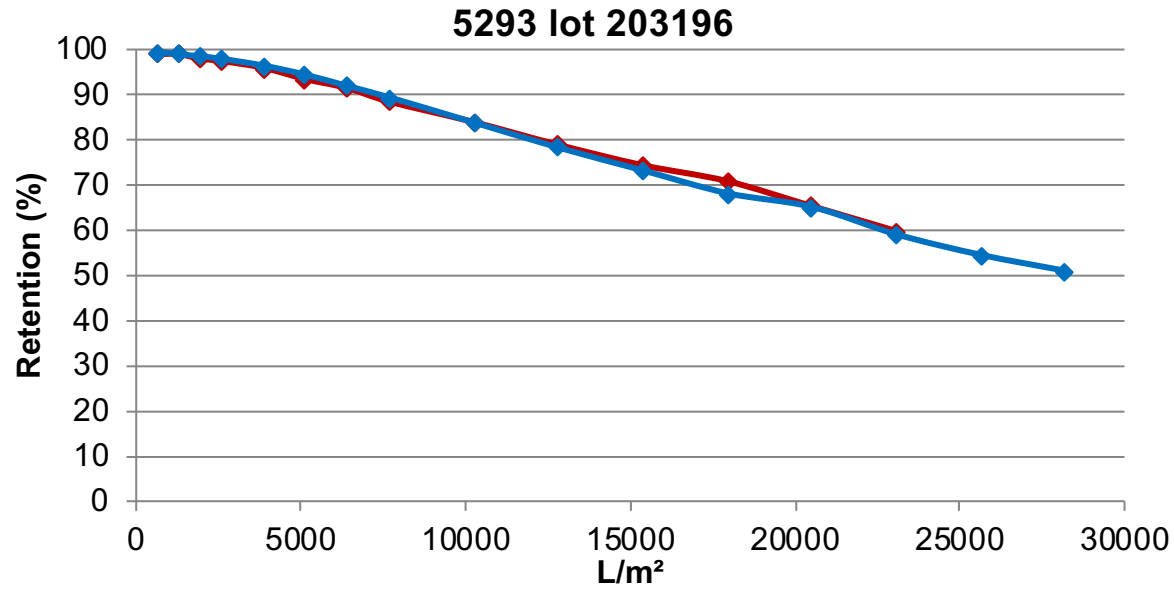
(*Conductivity 590µS/cm, Temperature 20°C, TDS 310 mg/L, pH 7.4*)

- Chlorine initial concentration: 2 ppm
- Flat sheet samples, surface area: 3.9 cm²
- Flow rate: 1 gpm = 15.9 mL/mn
- Analysis by spectrophotometry using kit test reagents from Hach.
- Concentration range between 0 and 2 ppm.

Chlorine Retention

Grade 5293

5293 is above 50% retention till 28 000 L/m²



Conditions:

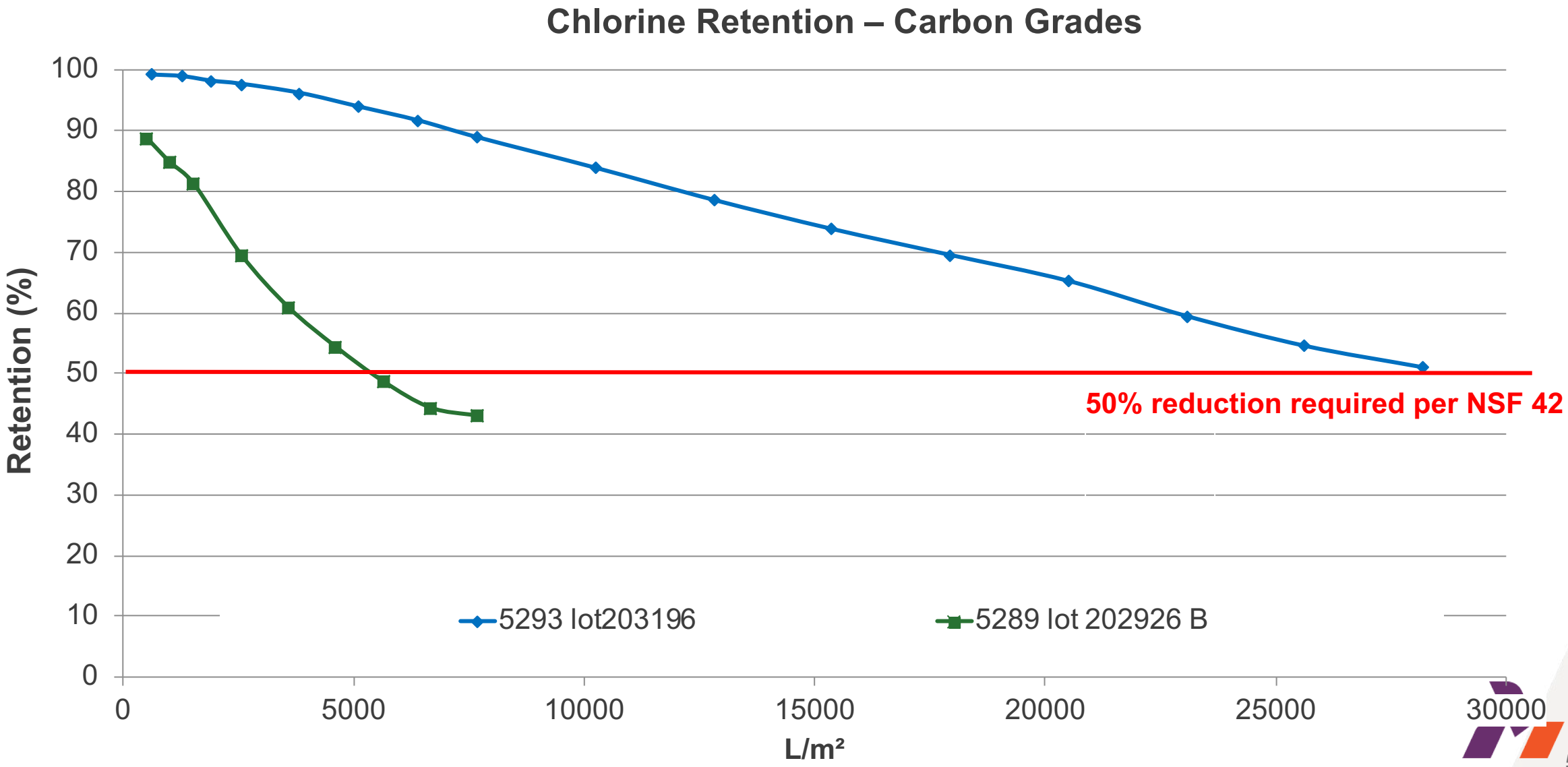
- Tap water from Pont Eveque-PEV

(*Conductivity 590µS/cm, Temperature 20°C, TDS 310 mg/L, pH 7.4*)

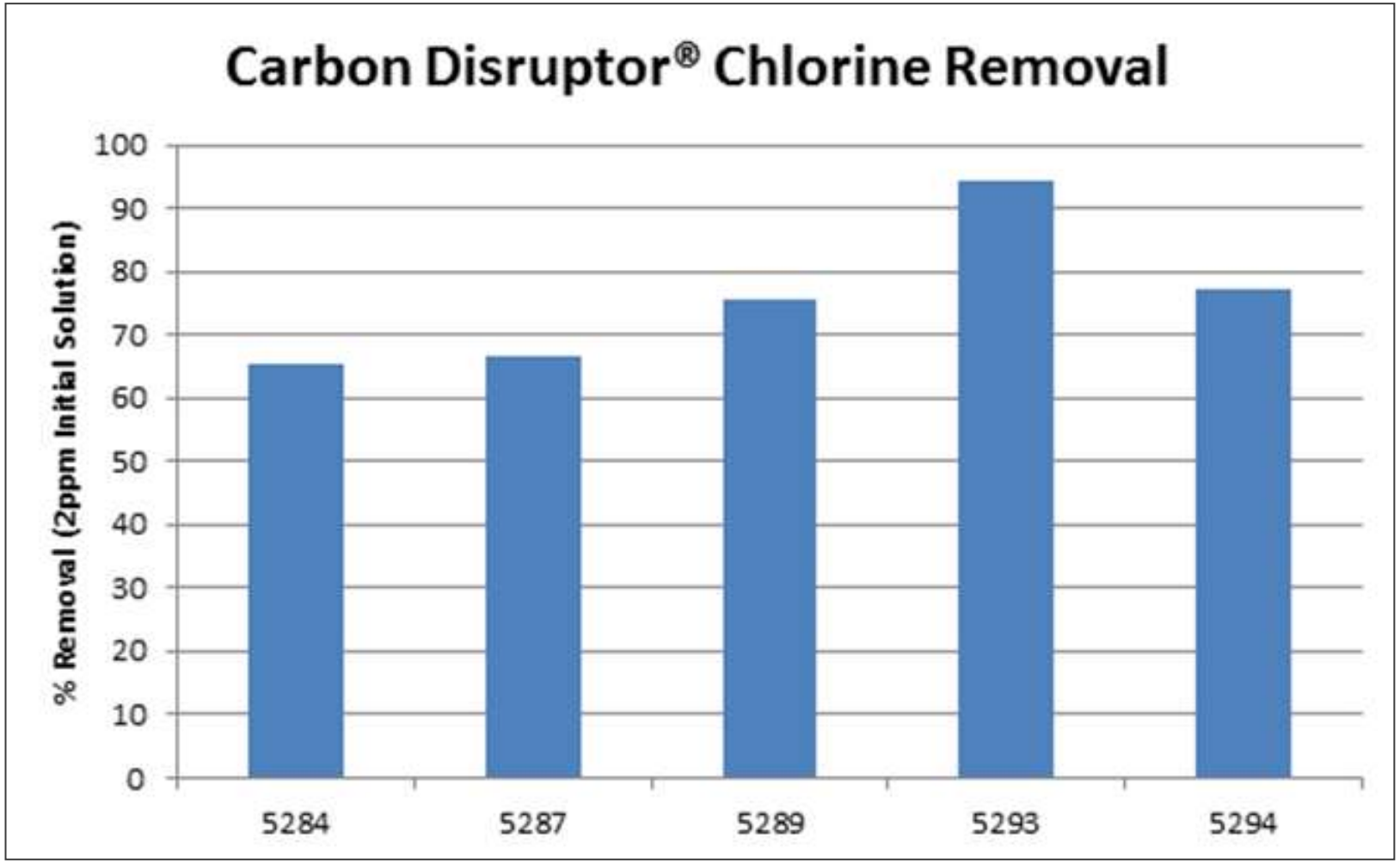
- Chlorine initial concentration: 2 ppm
- Flat sheet samples, surface area: 3.9 cm²
- Flow rate: 1 gpm = 15.9 mL/mn
- Analysis by spectrophotometry using kit test reagents from Hach.
- Concentration range between 0 and 2 ppm.

Chlorine Retention

Carbon Grades Summary



Chlorine removal for complete Disruptor® carbon product portfolio (in-house test protocol: TM-051)



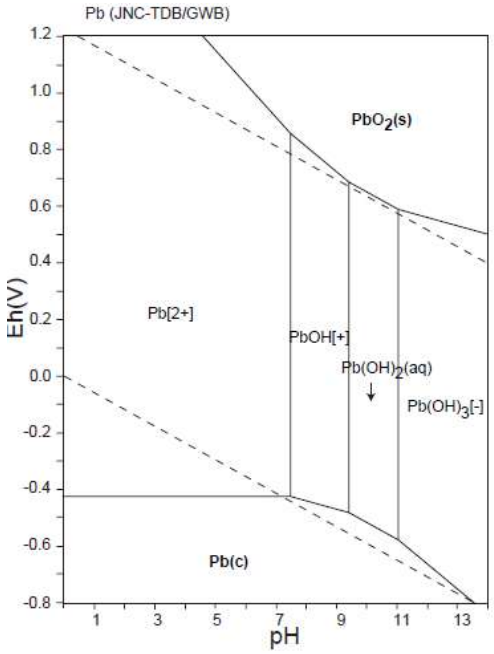
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  - ✓ PFC retention
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  - ✓ Disruptor® for RO systems

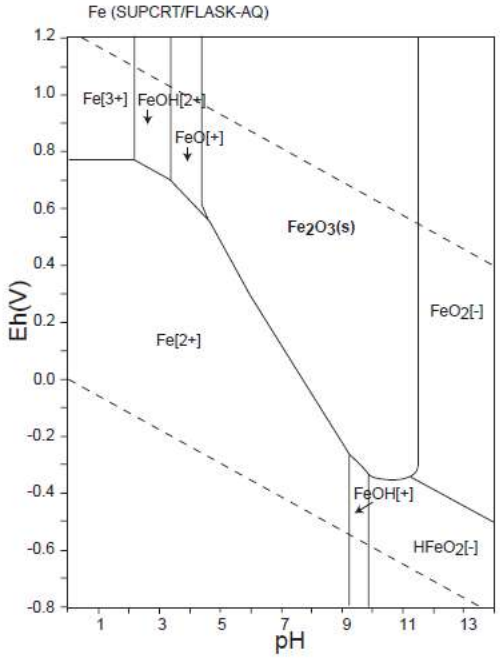


Depending on the pH the metal/heavy-metal exists in different forms

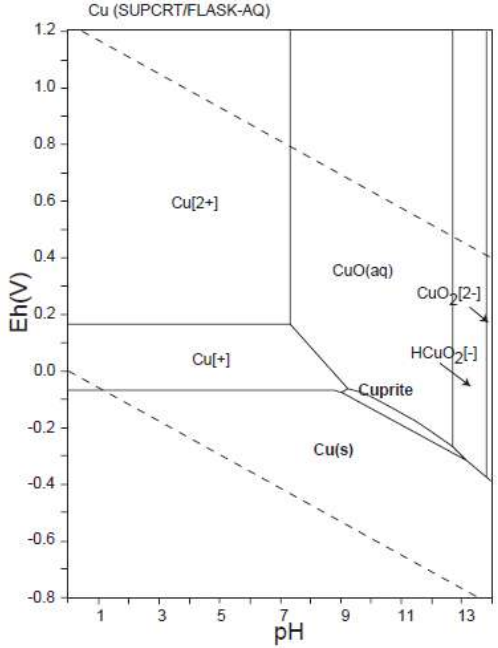
Lead



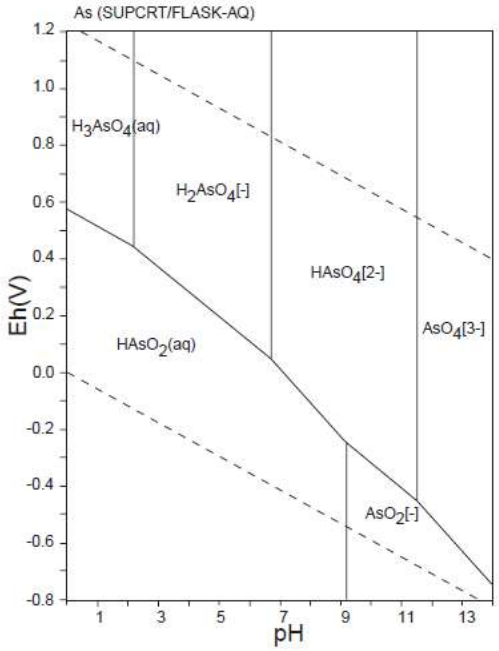
Iron



Copper



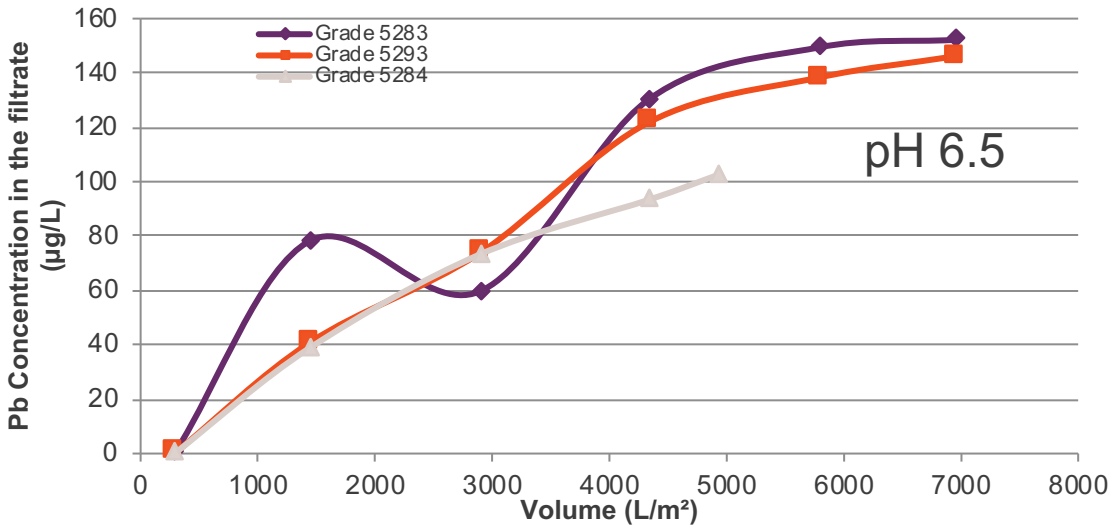
Arsenic



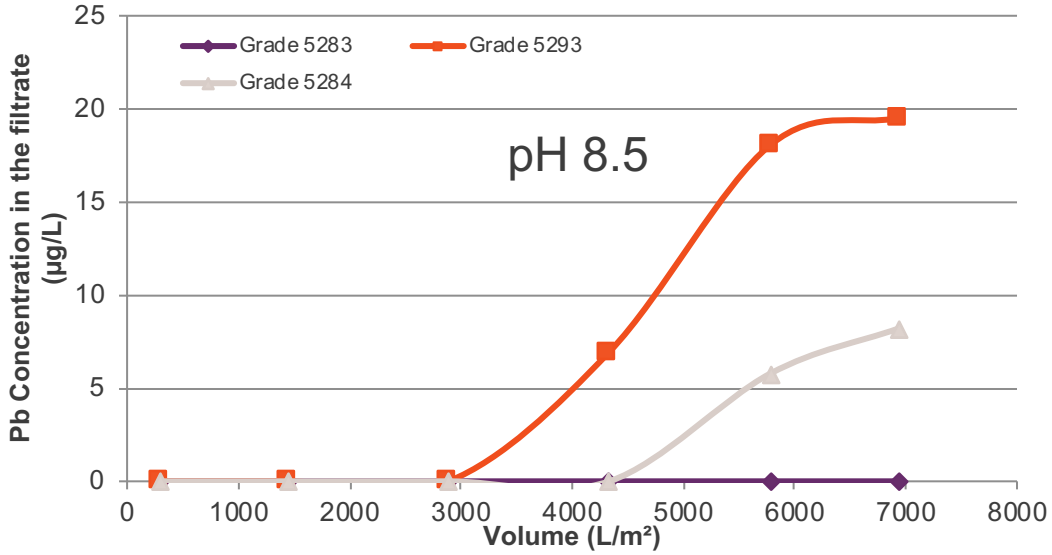
AQUADIAGNOSTICS
Water Research & Technology Centre Limited
Recognized by Water Quality Association, USA

Lead retention – Disruptor Grades 5283, 5284 and 5293

Dissolved



Particulate



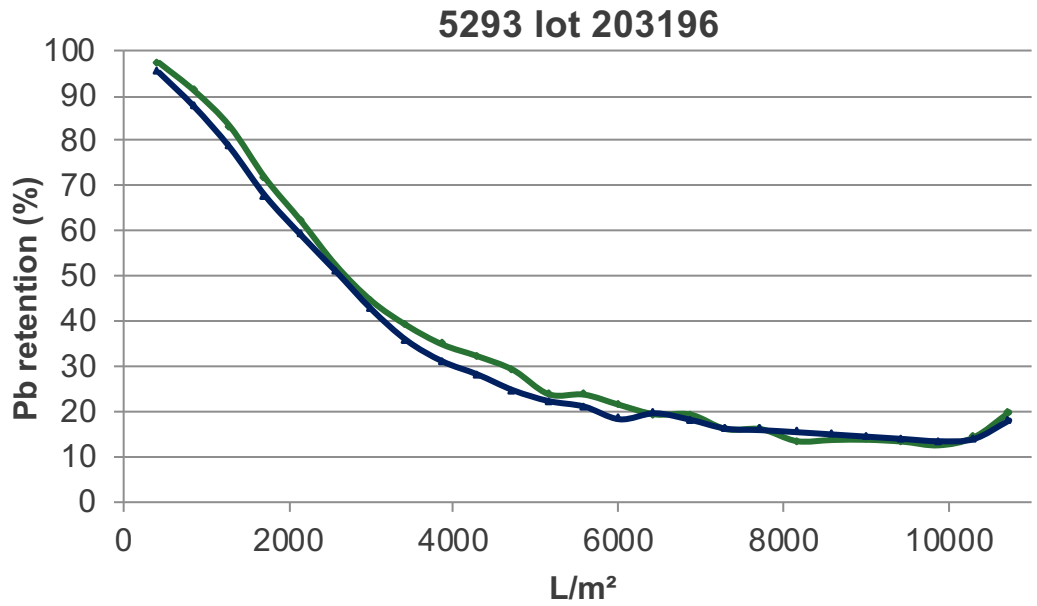
Test conditions:

- Flat sheet: 47 mm diameter (17.3 cm² surface area)
- Pressure maintained at 0.65 bar, and measurement of the flow rate variation
- Total concentration of lead NSF/ANSI 53 requirements: 150 µg/L ± 10% level

Lead (dissolved) Retention

Grade 5293

Lead retention is above 90% till 1100 L/m²
then it decreases rapidly to stay under 20% after 5000 L/m²



Conditions:

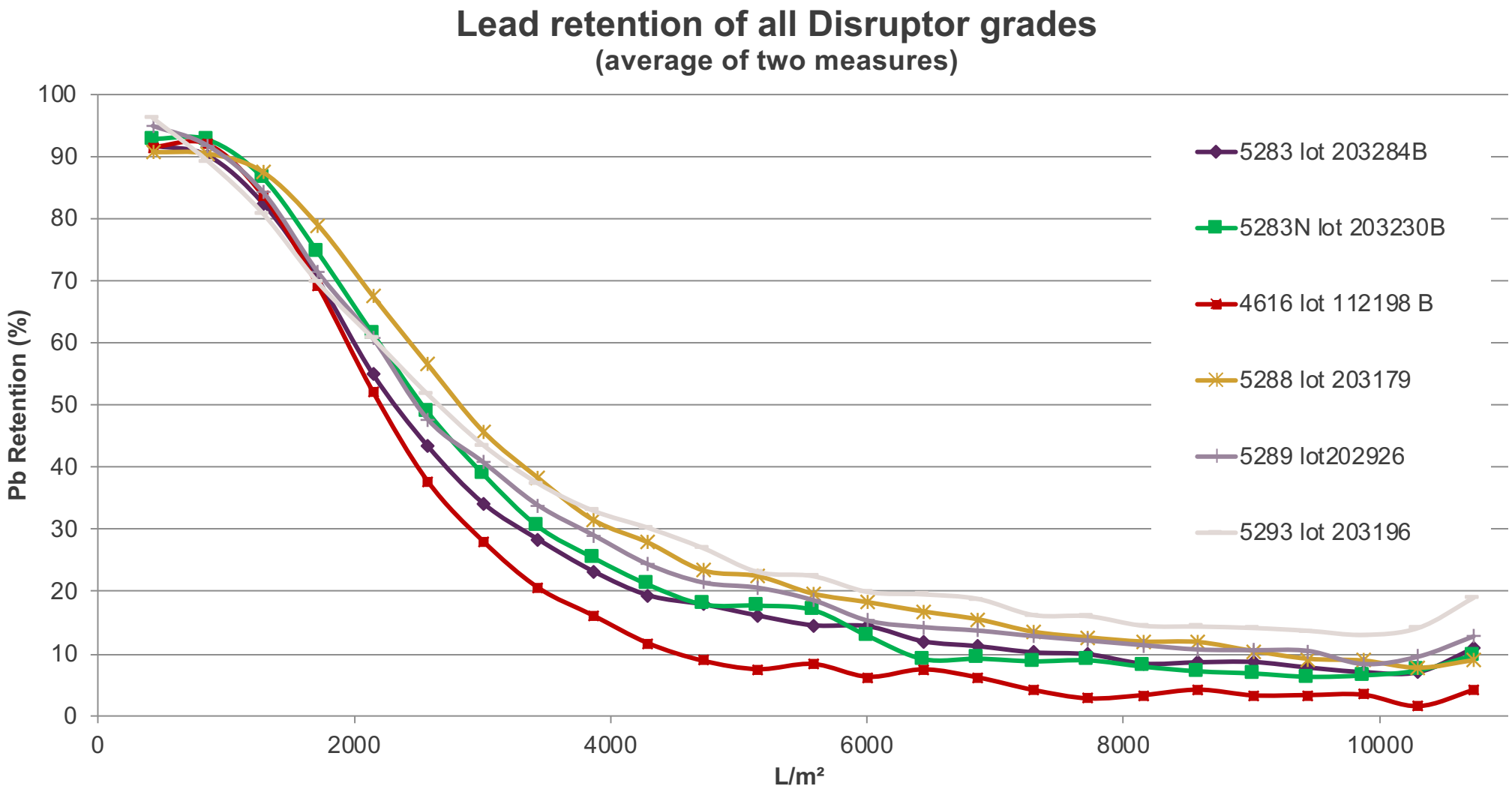
- Tap water from Pont Eveque-PEV

(*Conductivity 590µS/cm, Temperature 20°C, TDS 310 mg/L, pH 7.4*)

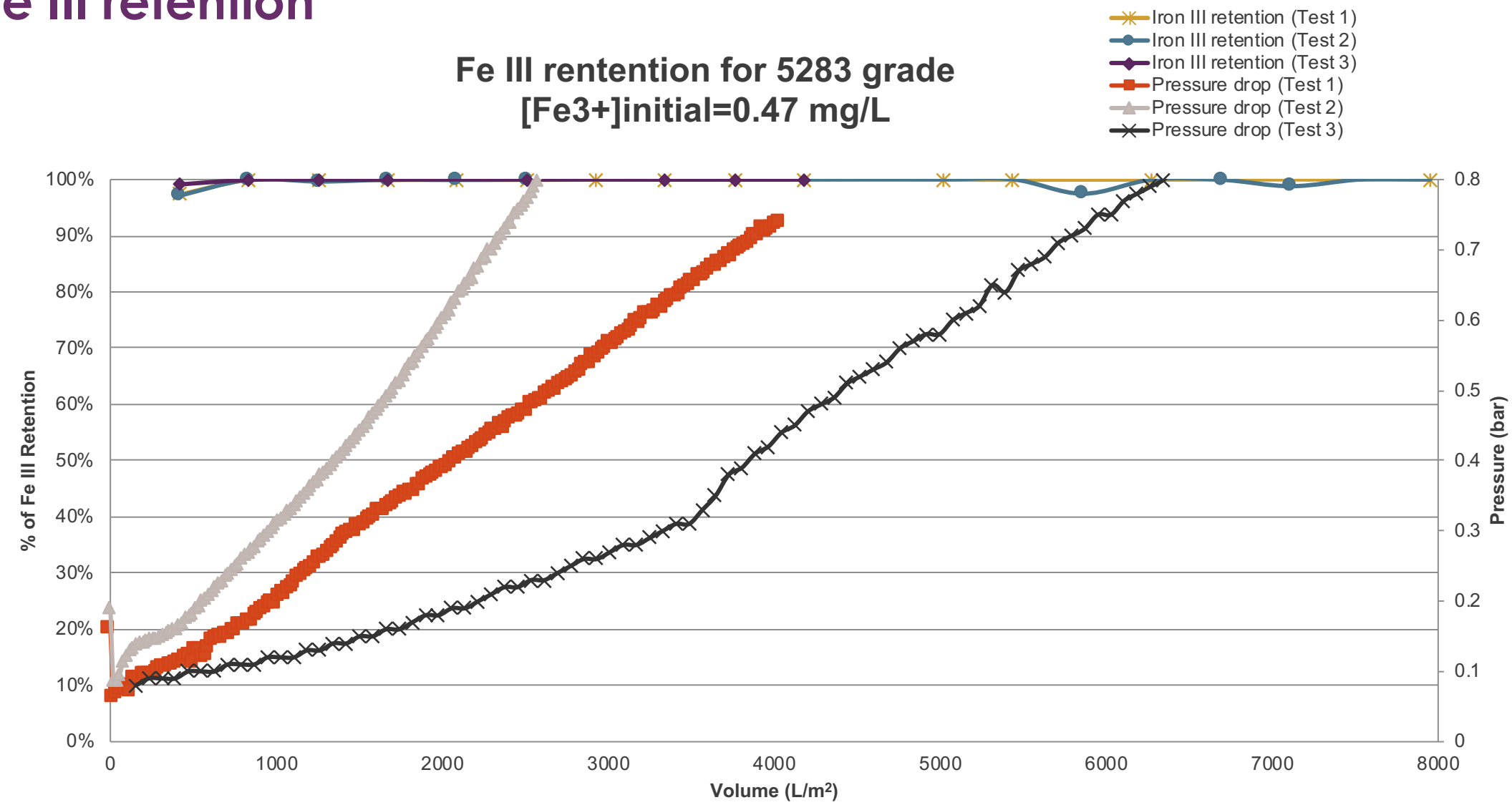
- Lead initial concentration: 150 ppb
- Flat sheet samples, surface area: 46.6 cm²
- Flow rate: 1 gpm = 190 mL/mn
- pH 6.5
- Analysis by ICP-AES

Lead Retention

Summary

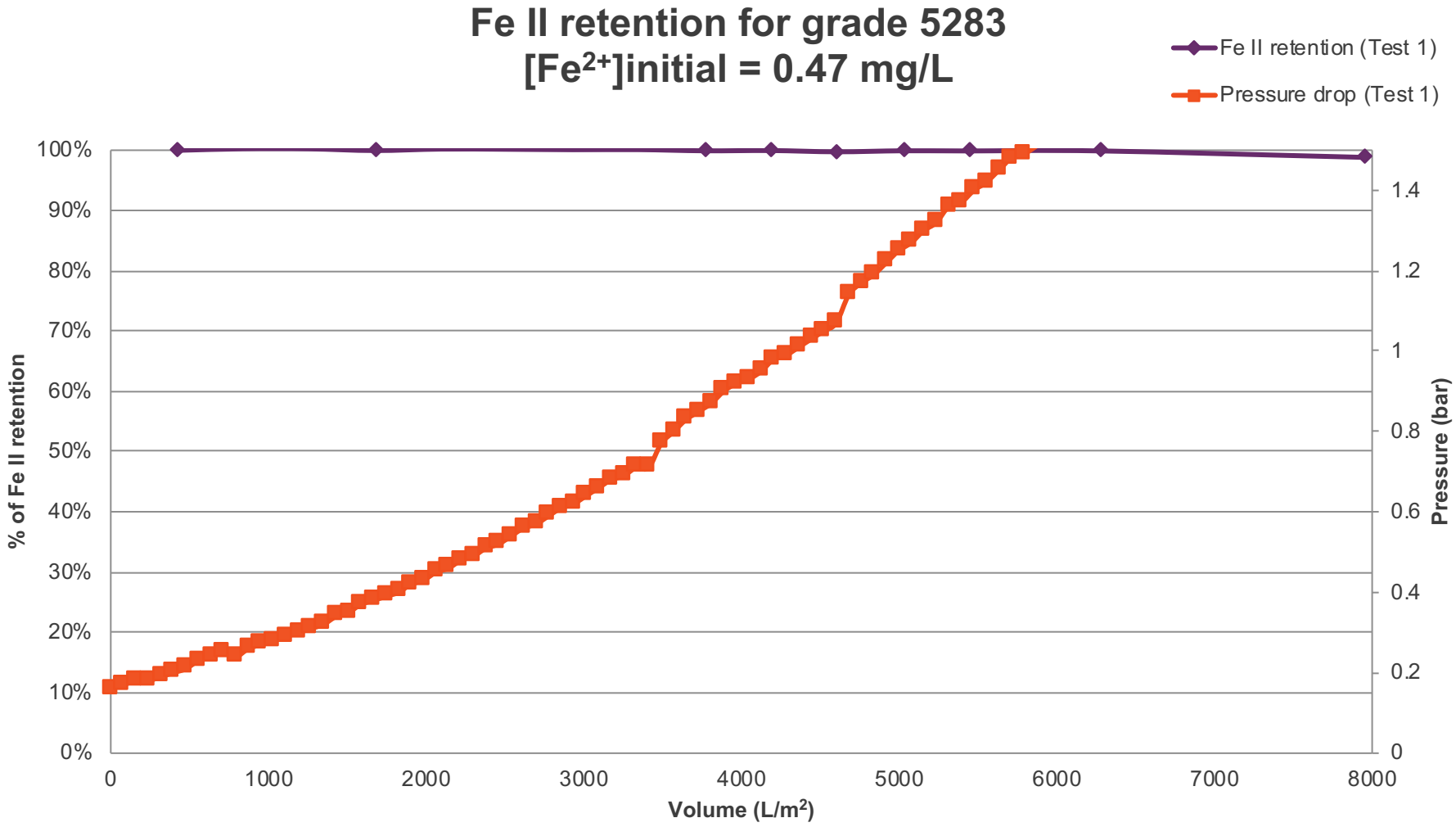


Fe III retention



Challenge water: Tap water with Fe III, pH=7.8, TDS= 300mg/L, Turbidity = 1.17 NTU

Fe II retention



Challenge water: Tap water with iron II, pH=7.8, TDS=324mg/L, Turbidity=1.12 NTU

Iron retention by Disruptor® – case study

The following information is from a man who works for a large commercial/industrial company who services buildings in the greater Washington DC region. The man who did the testing had a very bad problem with iron in his residential well water. He was preparing to install some big, expensive iron reduction system. His comment about the performance of the Disruptor® was: “If you are just looking for my opinion of the filter I would give it a 10!”

He used a Dual Gradient Density Polypropylene Sediment Cartridge as the pre-filter to a 4.5” X 20” Disruptor® filter made with white Disruptor®. The filters were in use for about 6 months before the pressure drop on the prefilter caused both filters to be replaced.

This is a reference because it shows the interest in using our media to reduce iron levels in the piping of heating and cooling water, fire systems, etc.



The picture is of the Disruptor® filter – after the prefilter!
6 months of use for filtration of highly contaminated well water

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  - ✓ PFC retention
  - ✓ Trace pharmaceuticals retention
  - ✓ Disruptor® for RO systems



Results of the PFC retention by 5284 (carbon) Grade

PFC Species	Initial Concentration (ng/L)	At 123 L/m² (ng/L)	At 530 L/m² (ng/L)	At 938 L/m² (ng/L)	At 1345 L/m² (ng/L)	At 1753 L/m² (ng/L)	At 2568 L/m² (ng/L)	At 3383 L/m² (ng/L)	4605 L/m² (ng/L)
PFOA	50	2.2	8.7	13	20	26	23	39	36
PFOS	237	ND	12	25	53	59	57	100	84
PFBA	20	7.0	19	18	16	21	19	23	18
PFPeA	66	11	37	49	63	70	78	70	79
PFHxA	61	4.8	19	29	42	49	52	54	53
PFHpA	30	1.9	6.4	9.1	15	18	27	23	26
PFNA	3.4	ND	ND	ND	ND	ND	ND	1.5	1.6
PFBS	14	ND	5.3	6.8	7.9	13	10	16	12
PFHxS	74	ND	10	19	29	45	30	55	59
PFDA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFUnA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFDoA	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFOSA	ND	ND	ND	ND	ND	ND	ND	ND	ND

Concentration of thirteen PFC species before (i.e., initial concentration) and during filtration experiments

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  - **Trace pharmaceuticals retention**
  - Disruptor® for RO systems
- Disruptor® experimental projects
- Disruptor® converting instructions for optimized performance
- Kemflo customer unmet needs – open discussion



NSF Standard 401 – Removal of Emerging Contaminants by 5293

Prescription Drugs

- *Meprobamate: a compound found in anti-anxiety drugs.*
- *Phenytoin: an anti-epileptic drug.*
- *Atenolol: a beta blocker drug.*
- *Carbamazepine: an anti-convulsant and mood-stabilizing drug.*
- *Trimethoprim: an antibiotic medication.*
- *Estrone: a prescription birth control drug.*[2]

Chemical Compounds

- *TCEP (Tris(2-chloroethyl)phosphate): a chemical compound used as a flame retardant, plasticizer and viscosity regulator in various types of polymers including polyurethanes, polyester resins and polyacrylates.*
- *TCPP (Tris(1-chloro-2-propyl) phosphate): a chemical compound used as a flame retardant.*
- *BPA (Bisphenol A): a chemical compound used as a plasticizer.*
- *Nonyl phenol: a collection of compounds often used as a precursor to commercial detergents.*[3]

Prescription Drug Testing NSF 401

Analyte	Sample Point				
	50%	100%	150%	180%	200%
Meprobamate	NO	NO	NO	NO	NO
Phenytoin	YES	YES	YES	YES	YES
Atenolol	YES	NO	NO	NO	NO
Carbamazepine	YES	YES	NO	NO	NO
Trimethoprim	YES	YES	YES	YES	NO
Estrone	YES	YES	YES	YES	YES

Chemical Compound Testing NSF 401

Analyte	Sample Point				
	50%	100%	150%	180%	200%
TCEP	YES	YES	NO	NO	NO
TCPP	YES	YES	YES	YES	YES
Bisphenol A	YES	YES	YES	YES	YES
Nonyl phenol	YES	YES	YES	YES	YES

All testing based on a life estimation of 1000 liters/ft2 corresponding to 100% in the tables.

NSF Standard 401 – Removal of Emerging Contaminants by 5293 (cont.)

Over-the-Counter Medications

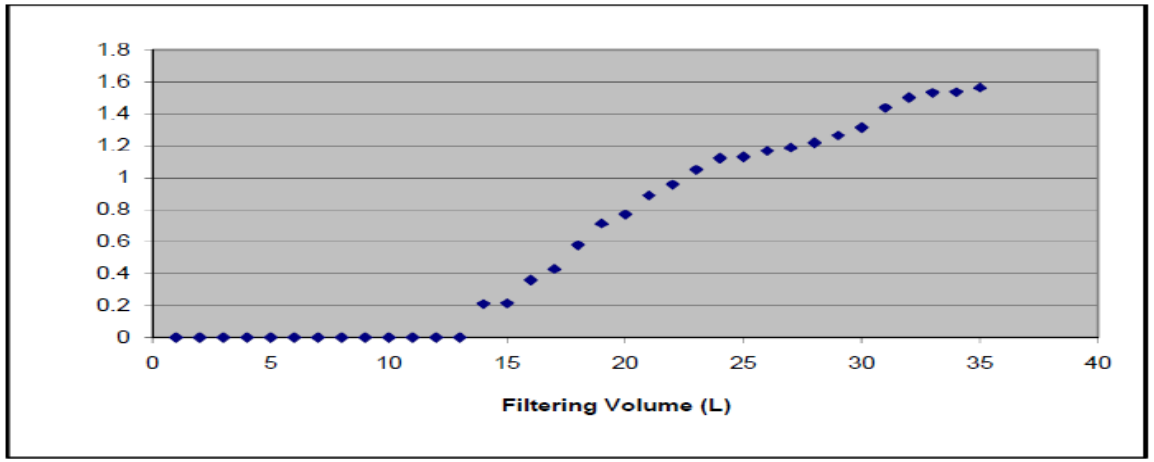
- *Ibuprofen: an over-the-counter pain reliever and anti-inflammatory medication.*
- *Naproxen: an over-the-counter pain reliever and anti-inflammatory medication.*
- *DEET (N,N-Diethyl-meta-toluamide): a pesticide and common active ingredient in insect repellents.*
- *Metolachlor: an organic compound that is widely used as an herbicide.*
- *Linuron: an herbicide often used in the control of grasses and weeds[4].*

OTC Medication Testing NSF 401					
Analyte	Sample Point				
	50%	**100%**	**150%**	**180%**	**200%**
Ibuprofen	YES	YES	NO	NO	NO
Naproxen	YES	YES	YES	YES	YES
DEET	YES	NO	NO	NO	NO
Metolachlor	YES	YES	YES	NO	NO
Linuron	YES	YES	YES	YES	YES

Other trace pharmaceutical / micro contaminant reduction results with Disruptor®

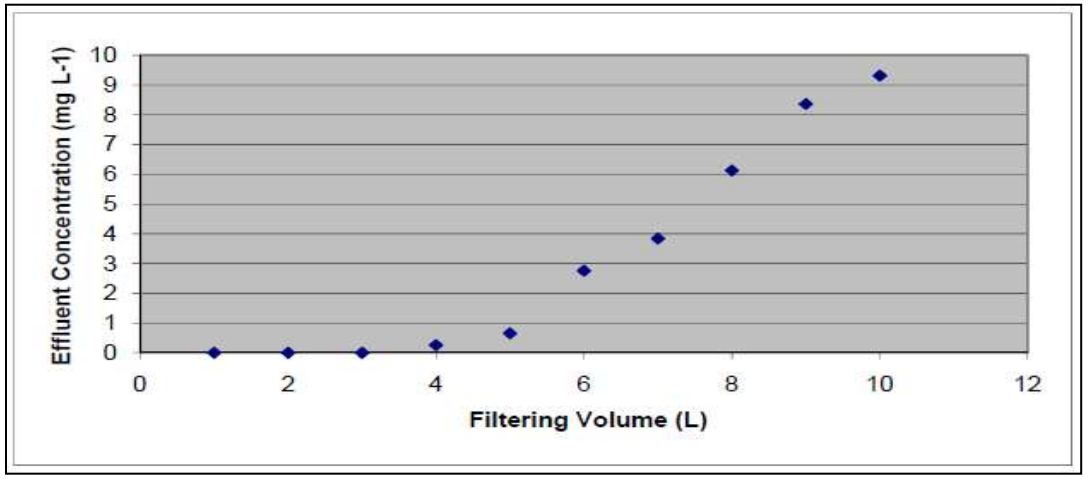
- Micro-contaminants of many types are now being detected in many waste water and in some potable water sources.
- The dangers these contaminants present to humans and the environment are not well understood
- Reduction of removal of these compounds from both waste and potable water is a concern to many health authorities and agencies

Penicillin G Removal



Penicillin G was used as a representative antibiotic. It was first studied using a challenge solution of 2 mg/l. This slide shows that the entire antibiotic was removed from 13 liters of water. At more typical concentration in the range of 2 micrograms per liter, a square foot of Disruptor® PAC could theoretically process more than 900,000 liters of water if it were free of other contaminants.

Flumequine Removal



Flumequine is a chemotherapeutic antibiotic implicated in tendon rupture, DNA damage and anaphylactic shock. It has been taken off the market but is representative of the flumequine drug class. The data shows complete removed from 3 liters of water having a concentration of 10 mg/L. At more typical concentration in the range of 2 micrograms per liter, a square foot of Disruptor® could theoretically process more than 1 million liters of water if it were free of other contaminants.

Other trace pharmaceutical / micro contaminant reduction results with Disruptor® (cont.)

PCB Removal

Congener Group	ng/L influent	5284 ng/L effluent	5283 ng/L effluent
Total monochloro biphenyls	158	2.36	0.377
Total Dichloro Biphenyls	629	0.85	nd
Total Trichloro Biphenyls	1260	nd	nd
Total Tetrachloro Biphenyls	4490	nd	nd
Total Pentachloro Biphenyls	4870	nd	nd
Total Hezachloro Biphenyls	4460	nd	nd
Total Heptachloro Biphenyls	2460	nd	nd
Total Octachloro Biphenyls	1810	nd	nd
Total Nonachloro Biphenyls	473	nd	nd
Decachloro Biphenyls	187	nd	nd
Total PCBs	20797	3.21	0.377

Polychlorinated biphenyls (PCBs) are man made organic chemicals that are known for their toxic and carcinogenic effects. Independent testing has shown Disruptor® and Disruptor® PAC to be effective in removing PCBs from water as indicated by the above chart.

Orthophosphate (fertilizer) reduction

Criteria	Median MBE Effluent Concentration	Disruptor RO-Prefilter Effluent
cBOD (mg/L)	2	
Turbidity (NTU)	0.07	
Ammonia (mg/L-N)	0.03	
Nitrate (mg/L-N)	1.33	
TKN (mg/L)	0.95	
Total Phosphorus (mg/L-P)	0.145	
Ortho-phosphate (mg/L-P) - 3/7/11	**0.118**	**0.002**
Ortho-phosphate (mg/L-P) - 3/10/11		**0.023**
TOC (mg/L)	7.93	8.15

Pilot trial data in tertiary waste water to evaluate orthophosphate reduction using Disruptor®

Content

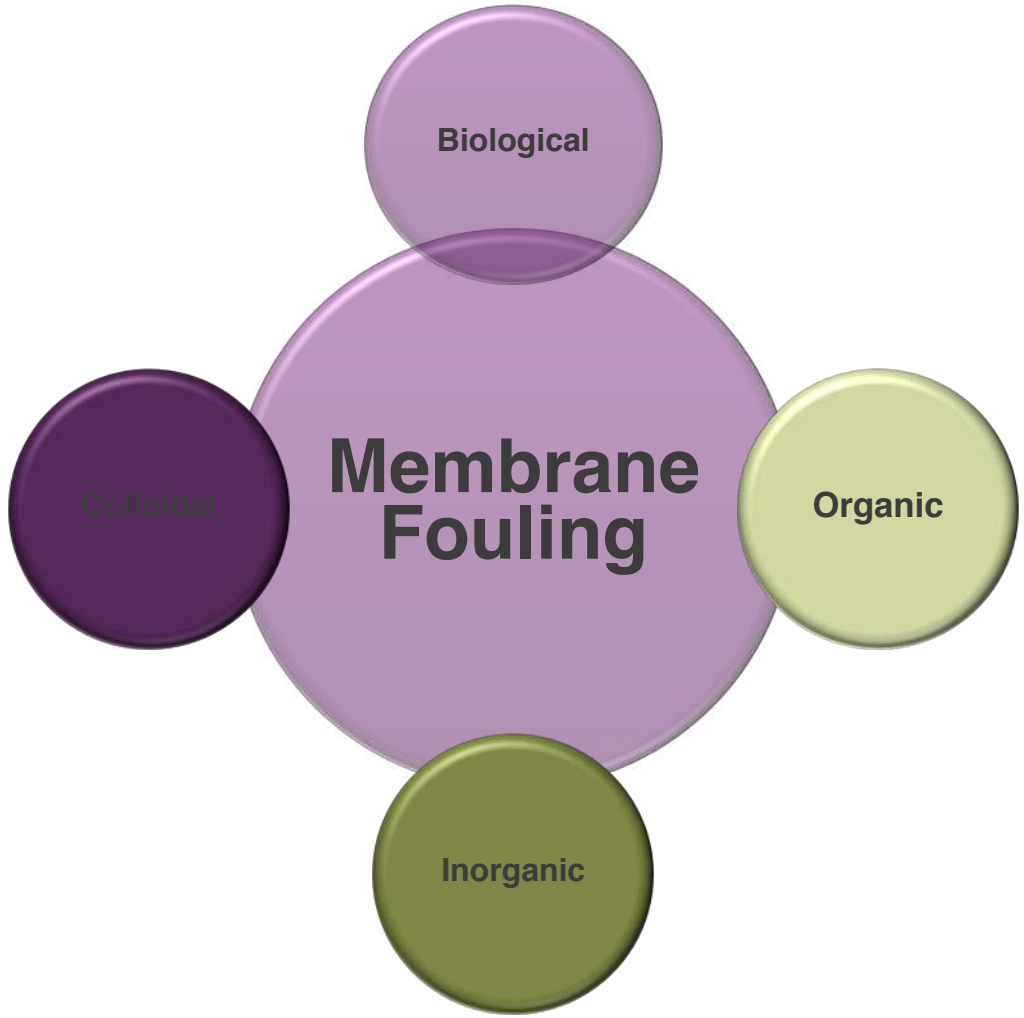
- Ahlstrom–Munksjö in a nutshell
- In-house analytical technical capabilities
- Disruptor® Overview
- Disruptor® Performance
  - ✓ Biologic retention
  - ✓ Chlorine retention
  - ✓ Metal/heavy-metal retention
  - ✓ PFC retention
  - ✓ Trace pharmaceuticals retention
  - ✓ Disruptor® for RO systems



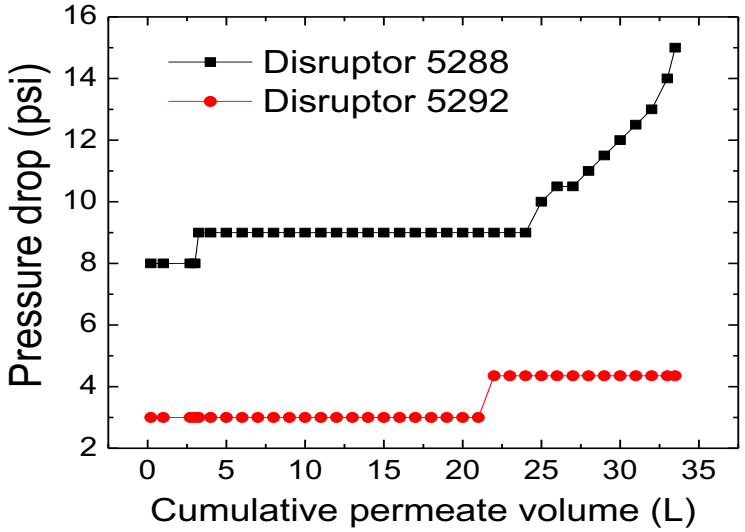
Membrane Fouling

- Fouling is a significant impediment to membrane process operation
  - System downtime, cleaning costs
  - Lost productivity (permeability loss)
  - Increased energy needs
- Many different organics in secondary effluent
- Natural organic matter
  - Biopolymers, cellular debris
  - Other organic materials
- Particulates & colloidal
  - Nano-particulate fouling

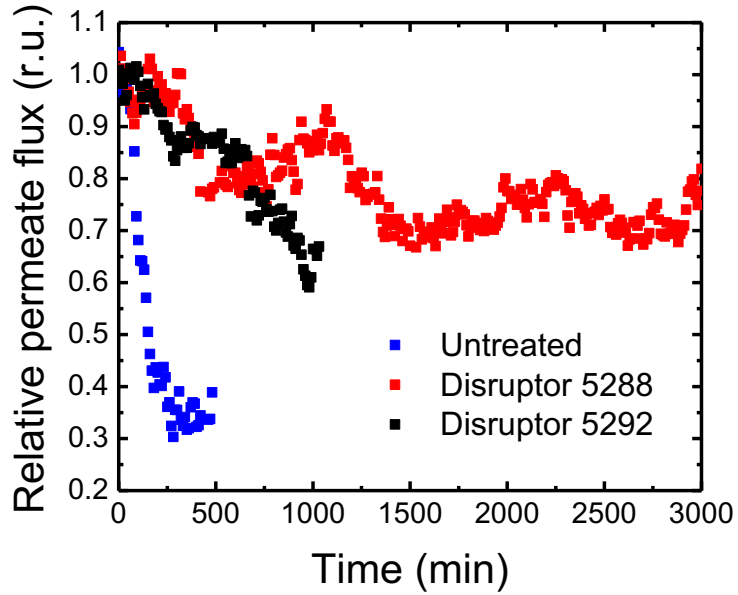
Dr. J. Brant University of Wyoming



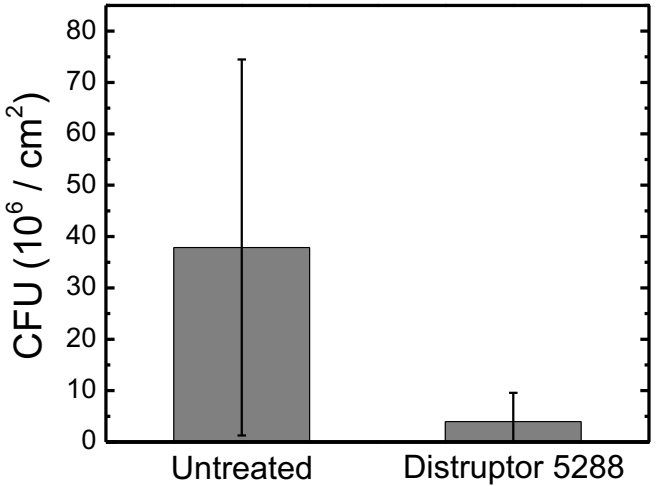
Results – Disruptor® as a pre-filter for RO



Pressure drop across the different Disruptor® media during the pre-treatment of a tertiary wastewater RO feed



Flux decline for untreated and Disruptor®-treated RO feed water. Experiment stopped at 30% flow rate decline.



Abundance of Colony Forming Units (CFU) on membranes fouled with a tertiary wastewater effluent untreated or pre-treated with the 5288 Disruptor®. Fouled membranes are collected upon reaching 30% flux decline, sonicated, the supernatant is spread on a R2A agar plate, and plates are incubated 7 days at 28oC before CFU enumeration.

Membrane Test System University of Wyoming

Test system used parallel water streams feeding the same water to both systems at the same time



UF Modules
Prefilter to RO



Electropositive Filter



RO Elements

Humic Acid Removal – Organic Fouling



Feedwater
10.7 NTU



UF Filtrate
0.23 NTU



EPF
0.16 NTU

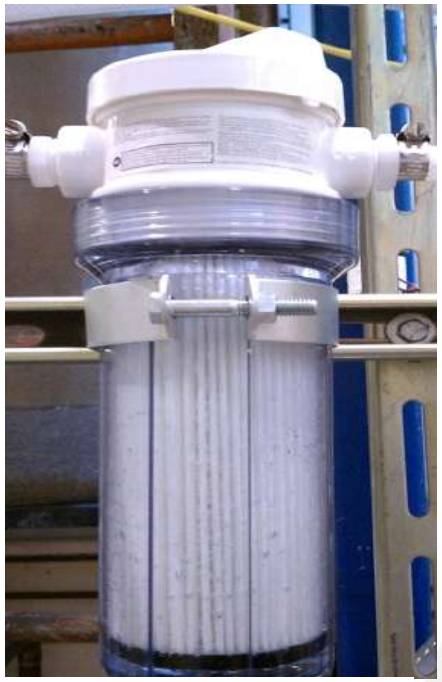


UF + EPF
0.16 NTU

NOTE: 0.16 NTU is detection limit of equipment.

- **EPF (Disruptor®) effectively removed humic acid that passed through UF membrane**
  - Turbidity reduction = 98.5%
  - Greater color removal by EPF compared to MF





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