Introduction to Disruptor®



Ahlstrom – Munksjö in a nutshell

Global leader in sustainable and innovative fiber-based solutions

What <mark>we d</mark>

- Fibers are at the core of what we do and the common denominator for our products and solutions
- Natural fibers represent 95% 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



Transportation

Healthcare & Life Science

> Consumer Goods



ndustrial

Global presence with 45 plants in 14 countries

- Global network of sales offices and 45 plants in 14 countries
- Approximately 7,800 employees
- More than 6,000 customers in over 100 countries
- Net sales of approximately EUR
 2.7 billion
- Head office in Helsinki, Finland





Ahlstrom-Munksjö in the value chain

petrochemicals



Consumers & Industrial customers



Disruptor® - Electro-Positive Technology



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 –
 9,5 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

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
- Thanks to the wet-laid production technique Disruptor removes contaminants both by the electro-positive charging mechanism but also mechanically due to the porosity gradient and depth filtration mechanism.





Disruptor – Depth filtration



MF/UF/NF membranes – Surface filtration







Disruptor® performance coverage compared to std. membrane product offerings





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 **trace metals** also possible in given pH ranges.
- Disruptor® media is **easy to convert** and can be made into virtually any size filter cartridge.





Why buy Disruptor®? Key value propositions

Performance

- Disruptor® removes a **wider range** of contaminants than membranes, carbon blocks, particulate cartridges and ultraviolet technologies such as bacteria/legionella, viruses, cyst, endotoxin, polysaccharides, colloids, trace pharmaceuticals, particulates, PFOA/PFOS, chlorine, etc.
- Hundreds of billions of bacteria, viruses, Cysts, and other pathogens can be removed per m² of Disruptor® filter media at a very high % removal rate.
- The contamination removal functionality is based on **electro-positive charge** but also **mechanical filtration** since the media MFP (Mean Flow Pore) is in the 1-2 micron size range. Thanks to the porosity gradient for enhanced depth filtration Disruptor® offers extended filter life opposed to membranes relying only on surface filtration for contaminant removal.

Energy Savings - Sustainability

- Disruptor® offers very high flux rates at lower pressure drops compared to competing technologies with similar biological removal performance and media pore sizes.
- Disruptor® can therefore be designed for **both gravity flow** as well as **pressurized** water purification systems.
- Due to the high surface area less material is needed compared to competing technologies such as e.g. hollow fibers or flat membranes

Product Safety - Taste

- Disruptor® removes effectively the pathogens and other contaminants, but in parallel **maintaining the minerals** for taste in the water **without issues of handling "brine" waste-water** using RO systems.
- Compared to UF/hollow fibers Disruptor® does not block easily and filter remains odorless even if not used for several days.
- All Disruptor® grades are complying under NSF/ANSI 42 applicable drinking water requirements.

Flexibility & Multi-functionality

- Disruptor® can be used as a stand-alone solution or in combination with other technologies depending on the level of water purification needs. It can be used in pleated configurations to fit any filter housing size, or in the format of die cut flat samples.
- Since Disruptor® is also a unique "one of it's kind" technology in the market-place it offers excellent opportunities for product differentiation in both pressurized and gravity flow applications.



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

Bacteria

- Raoultella terrigena
- Influent concentration of 10⁵ or 10⁶ per ml
- Required reduction 99.9999% or 6 log



Virus

- MS2 Bacteriophage
- Influent concentration of 10⁵ or 10⁶ per ml
- Required reduction
 99.99% or 4 log



Cyst

- 3 microns bead surrogate
- Influent concentration of 10⁵ or 10⁶ ml
- Required reduction 99.95% or 3.5 log



In comparison: Ganges River in India carries a total coliform concentration in the 1 x 10⁶/ml range



Virus (MS2) capacity testing for 5283 at 3rd party BCS labs.



Single Laver													
90 mm	Influent	1 Liter Effluent	5 Liter Effluent	10 Liters Effluent	15 Liters Effluent	20 Liters Effluent	25 Liters Effluent	30 Liters Effluent	35 Liters Effluent	40 Liters Effluent	45 Liters Effluent	50 Liters Effluent	55 Liters Effluent
Filter A	2.0 10 ⁵	<0.45	<0.45	1,4	1,4	0,91	4,5	6,3	12,2	24,1	27,2	28,6	N/A
Filter B	3.0×10^{-5}	<0.45	<0.45	1,4	1,4	2,7	3,6	6,3	16,8	28,1	31,8	32,7	N/A
Single Layer		_				MS2 PER	CENT REDU	CTION (%)					
90 mm	Influent	1 Liter	5 Liter	10 Liters	15 Liters	20 Liters	25 Liters	30 Liters	35 Liters	40 Liters	45 Liters	50 Liters	55 Liters
	Influent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent
Filter A	5	>99.9999%	>99.9999%	99,9995%	99,9995%	99,99997%	99,999%	99,998%	99,996%	99,991%	99,991%	99,99 %	N/A
Filter B	3.0 x 10 ⁻³	>99.9999%	>99.9999%	99,9995%	99,9995%	99,9991%	99,999%	99,998%	99,994%	99,99 %	99,99 %	99,99 %	N/A

Corresponding to ca. 8000 liters/m² capacity or in total 2,36 x 10^{12} (2,36 trillion) MS2 virus removed per m2 media at LRV 4.



Bacteria (E-Coli) capacity testing for 5283 at 3rd party BCS labs.

Single Layer 90		Day 1 Date:02/14/2017 EC 11229 PERCENT REDUCTION (%)												
mm	Influent	1 Liter	15 Liter	30 Liters	45 Liters	60 Liters	75 Liters	90 Liters	105 Liters	120 Liters	135 Liters	150 Liters	165 Liters	180 Liters
	million	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent
5283 Filter A	6.0.405	>99.99993%	>99.99993%	>99.99993%	>99.99993%	>99.99993%	99,9991%	99 <mark>,</mark> 998%	99 <mark>,</mark> 996%	99,998%	99,992%	99,99 %	99,98 %	99,91 %
5283 Filter B	6.0 X 105	>99.99993%	>99.99993%	>99.99993%	>99.99933%	99 <mark>,</mark> 9998%	99,999%	99,998%	99 , 996%	99 , 996%	99 <mark>,</mark> 995%	99,99 %	99,96 %	99,9%

Corresponding to ca. 7100 liters/m² capacity or in total 4,25 x 10^{12} (4,25 trillion) E-Coli bacteria removed per m2 media at LRV 6.



Where can Disruptor® be used?



Opportunities to tailor-make Disruptor® solutions covering the complete range of water purification applications!



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 and chlorine and/or heavy-metal removal (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[®] - Product Portfolio – Commercial Grades

Properties	5283	5283N	5284	5287	5288	5289	5293	5294
PM Code	4603	4603	4604	4607	4608	4609	4613	4614
Grade Type	White	White	Carbon	Carbon	White	Carbon	Carbon	Carbon
Carbon Type	n/a	n/a	Coconut	Coconut	n/a	Coconut	Wood	Coconut
Heat-seal	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Silver	No	No	No	Yes	Yes	Yes	Yes	Yes
Special Product Features	n/a	Netting Lamination	n/a	No Binder Fiber	n/a	n/a	n/a	No Binder Fiber
Basis weight – gsm	318	307	313	318	313	313	313	313
Thickness – mm	0,99	1,01	0,95	0,95	0,95	0,95	0,95	0,95
MFP – micron	1,2	1,1	1,4	1,5	1,2	1,4	1,6	1,4
Gravity flow – sec. (TM-134)	222	227	353	275	377	276	200	310
MD Tensile strength – N/m	3100	2700	2100	2100	2800	2100	3100	2200
Biological removal Initial LRV: RT, MS2, Cyst (TM-133)	Log 6 / Log 4 / Log 3,5	Log 6 / Log 4 / Log 3,5						
Biological removal E-Coli Capacity (1-5 rating)	5	5	4	4	5	4	3	4
Chlorine reduction Capacity at 50% (NSF42)	n/a	n/a	9,000 liter/m2	9,000 liter/m2	n/a	12,000 liter/m2	28,000 liter/m2	9,000 liter/m2

Disruptor[®] - Product Portfolio – Experimental Grades

Properties	2194-460	2194-461	2194-464	2194-468	9954
PM Code	9944	9949	9955	9954	9954
Grade Type	White	White	White	White	White
Carbon Type	n/a	n/a	n/a	n/a	n/a
Heat-seal	Yes	Yes	Yes	Yes	Yes
Silver	No	No	No	No	No
Special Product Features	Heavy Metals Sheet	Synthetic pre-filter	Glass-based pre-filter	Lead sheet (< 5 ppb threshold)	Lead sheet without lamination
Basis weight – gsm	309	313	313	306	228
Thickness – mm	1,02	1,16	1,20	1,00	0,79
MFP – micron	0,9	9,3	4,9	1,8	1,8
Gravity flow – sec. (TM-134)	n/a	34	64	163	93
MD Tensile strength – N/m	2600	4200	2300	4400	2700
Biological removal Initial LRV: RT, MS2, Cyst (TM-133)	n/a	n/a	n/a	n/a	n/a
Biological removal E-Coli Capacity (1-5 rating)	n/a	n/a	n/a	n/a	n/a
Chlorine reduction Capacity at 50% (NSF42)	n/a	n/a	n/a	n/a	n/a

Disruptor ® Legionella removal



Legionella Removal

Premise Plumbing POE filters

Cooling tower , cold water loops



Faucet Filter POU



- 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

Temperature range for legionella



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

Legionella Removal

Capacity Legionella Removal

Sample Code/ Customer Code	Tested parameter	Input Water Microbial Count	Output Water Microbial Count	% Reduction
5289	Legionella pneumophila ATCC 33152	7x 10⁵cfu/ml 5.84 log₁₀	169 cfu /ml 2.23 log₁₀	99.975% 3.61 LRV

TEST DATA: Microbial reduction @ Flow rate- 65ml / min

Cfu: Colony forming units.

TEST DATA: Microbial reduction @ Flow rate- 65ml / min

Sample Code/ Customer Code	Tested parameter	Input Water Microbial Count	Output Water Microbial Count	% Reduction
5288	Legionella pneumophila ATCC 33152	7x 10⁵cfu/ml 5.84 log₁₀	147 cfu /ml 2.16 log₁₀	99.979% 3.68LRV

Cfu: Colony forming units. LRV= Log reduction value, Sampling after 10L filtration.

<u>Conditions:</u> pH=7.10 ; TDS=260 mg/L ; TOC=1 mg/L ; Turbidity<1 NTU ; Temperature=23°C Sampling: 10L, disc=45mm, 6300 L/m²

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

Bisphenol A (BPA) removal



BPA is monomer used in the manufacture of polycarbonate and epoxy resins. It is know to be estrogenic and is controversial and well studied in conjunction with many health related issues including: reproduction, heart disease and diabetes. 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.

Testing Parameter Sample Units Control Result

Phthalates by Base/Neutral/Acid modifed 625 Method Modified (DHP, Di(n-prop

Dihexyl phthalate	ND(4)	ND(4)	ND(4)	ug/L
Di(n-propyl heptyl) phthalate	ND(4)	ND(4)	ND(4)	ug/L
Bis(2-ethylhexyl)terephthalate	ND(4)	ND(4)	ND(4)	ug/L
Diisodecyl phthalate (DIDP)	ND(4)	ND(4)	ND(4)	ug/L
Diisononyl phthalate (DINP)	ND(4)	ND(4)	ND(4)	ug/L
Diisooctyl phthalate (DIOP)	ND(4)	ND(4)	ND(4)	ug/L

Bisphenol A - propylene oxide adducts, LC/UV				
Bispheno A diglycideryl ether	ND(20)	ND(20)	ND(20)	ug/L
Bisphenol A propoxylate	ND(20)	ND(20)	ND(20)	ug/L
Bisphenol A diglycidyl ether	ND(20)	ND(20)	ND(20)	ug/L
Bisphenol A, LC/UV				
Bisphenol A	ND(10)	ND(10)	ND(10)	ug/L

Thank you!

AHLSTROM MUNKSJÖ