Introduction to Disruptor®

Amilo
Au Cœur de votre Eau

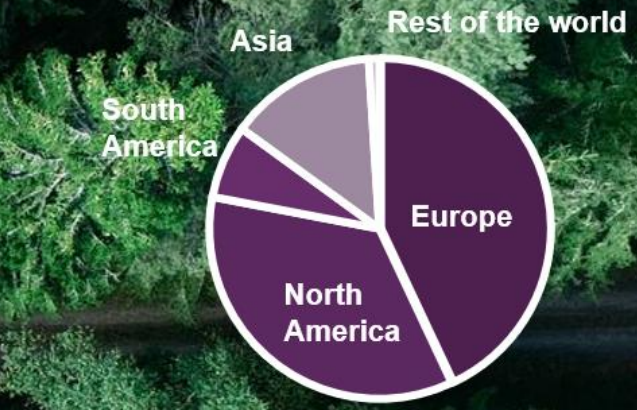
AHLSTROM MUNKSJÖ

Ahlstrom – Munksjö in a nutshell

Global leader in sustainable and innovative fiber-based solutions

What we do

- 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



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

Disruptor® - Electro-Positive Technology

What?

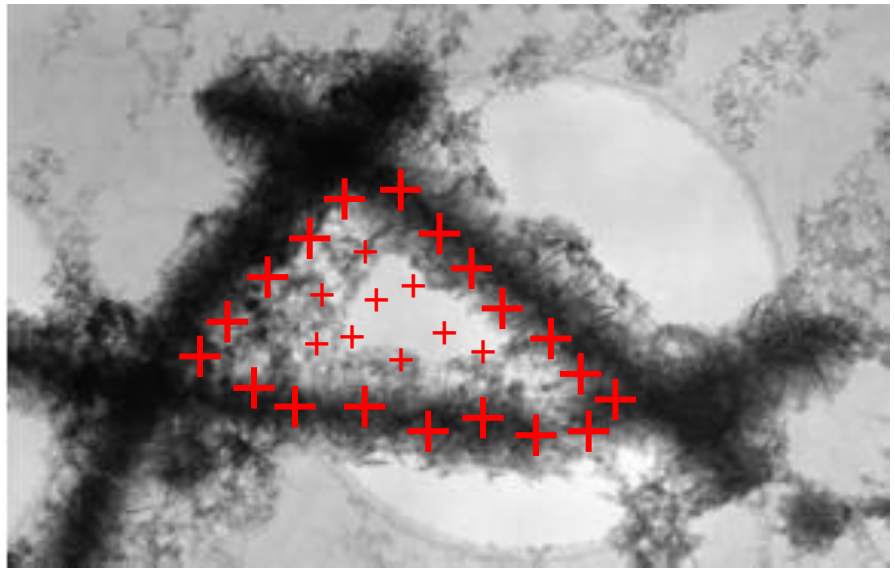
Why?

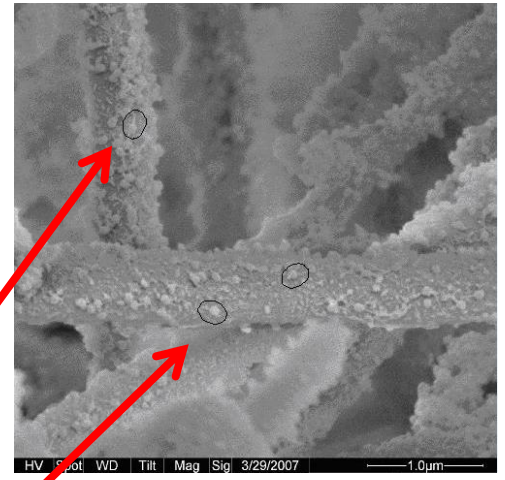
How?

Where?

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**.





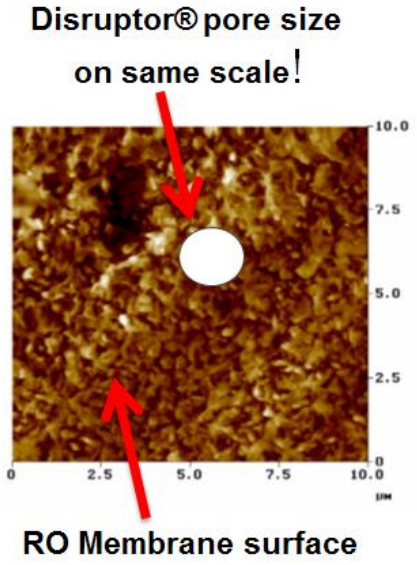
Bacterial cells: typically 1-10 micron in length & 0,2-1 ,0 micron in width

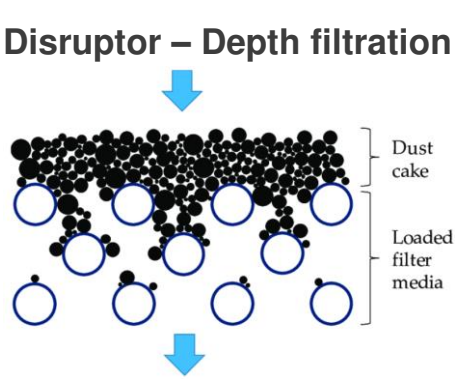
Viruses: typically 0,004 – 0,1 micron in size

Cysts: typically 2 – 50 micron in diameter

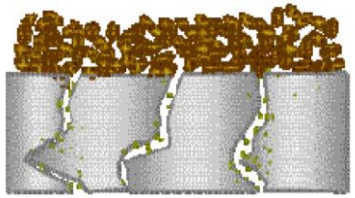
Biological testing vs. pathogen and contamination types

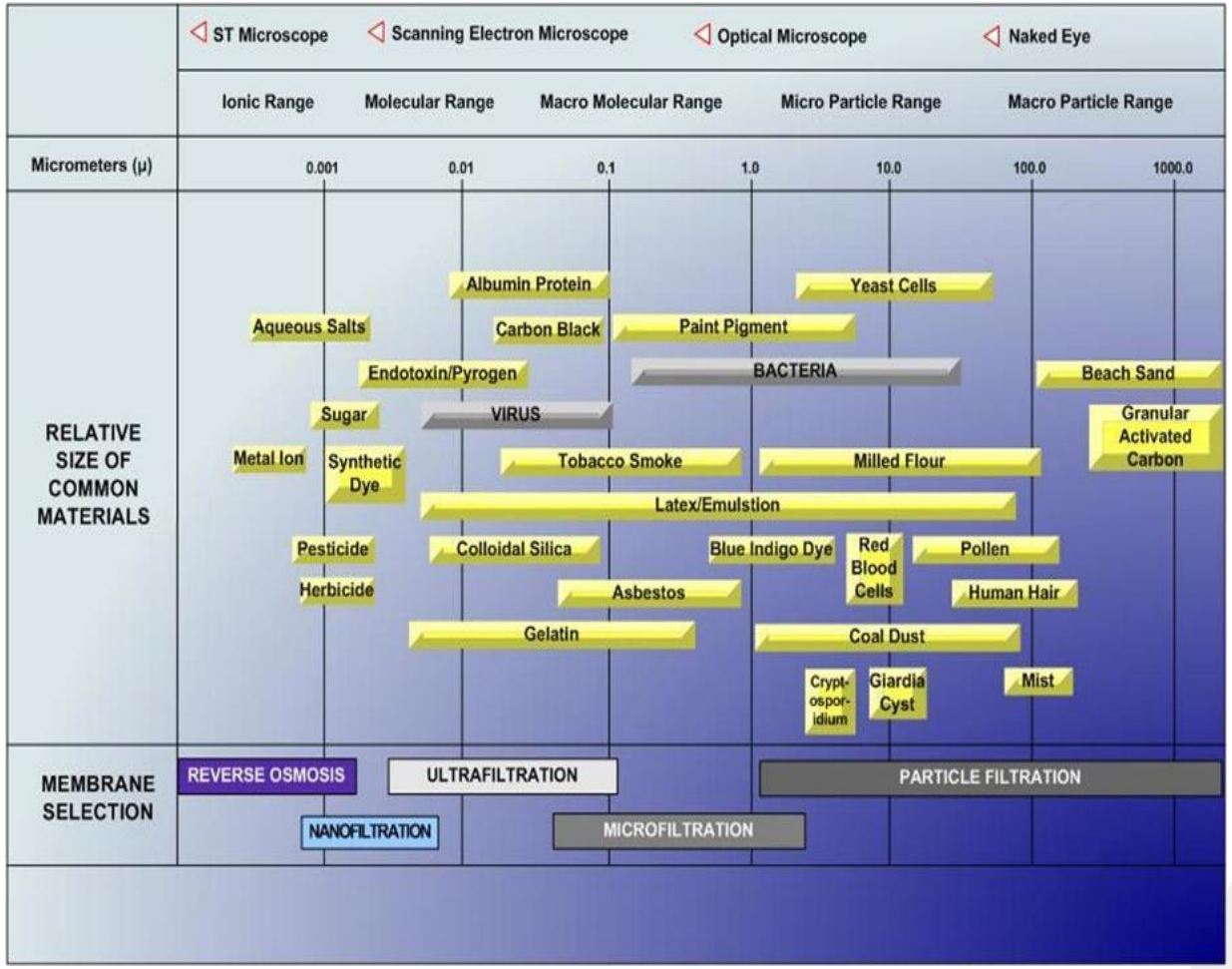
- Reduction of virus typically requires the use of ultrafiltration or reverse osmosis membranes
- Disruptor® technology reduces virus, bacteria and endotoxin with high flow and low pressure drop as compared to polymeric membranes
- Thanks to the wet-laid production technique Disruptor removes contaminants both by the electro-positive charging mechanism but also mechanically due to the porosity gradient and depth filtration mechanism.



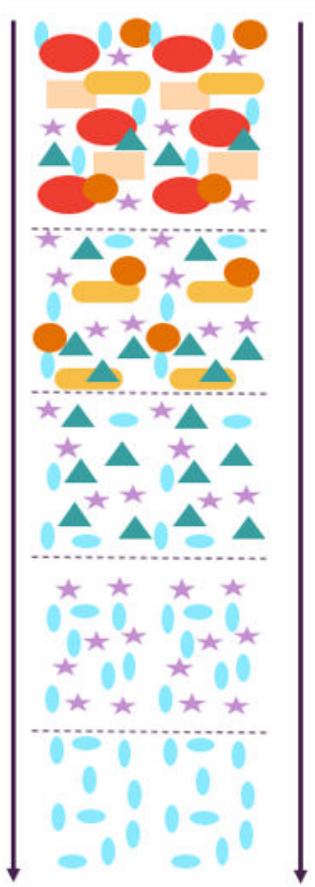


MF/UF/NF membranes – Surface filtration





Disruptor® performance coverage compared to std. membrane product offerings



Non-membrane

Membrane

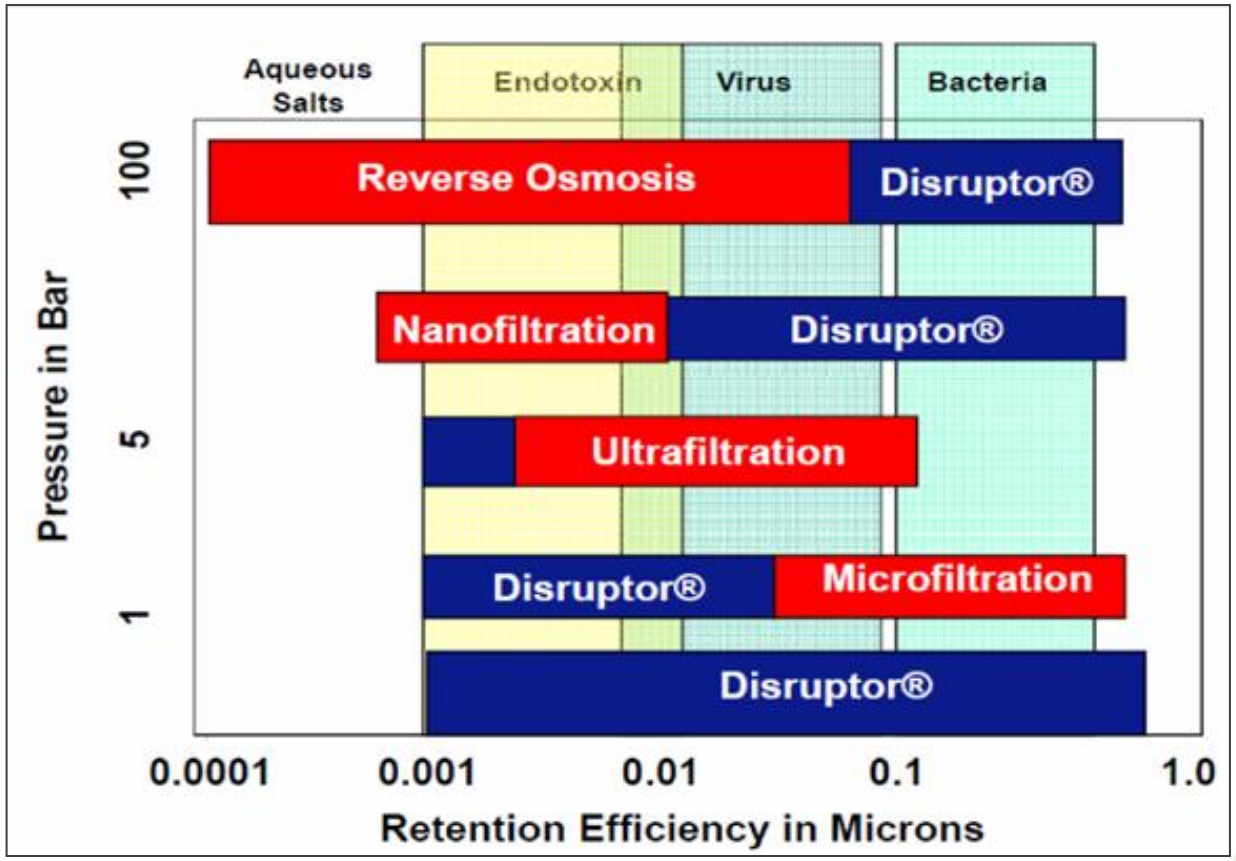
Mechanical filtration classes	Particle size	Typical applications
Particle filtration Removes large particles, e.g. blood cells (5-15 µm) or sand (100 – 1,000 µm)	>1 – 1,000 µm	▪ Surface filtration: collection of larger particles on the medium's surface ▪ Depth filtration: particles penetrate the surface of the medium
Microfiltration (MF) Removes bacteria and suspended solids	>0.1 – 1 µm	▪ Water and wastewater treatment ▪ Chemical processing
Ultrafiltration (UF) Removes viruses	>0.01 – 0.1 µm	▪ Water and wastewater treatment ▪ Chemical processing ▪ Pharma & biotech
Nanofiltration (NF) Removes multivalent ions	0.01 – 0.001 µm	▪ Water treatment
Reverse osmosis (RO) Removes monovalent ions etc.	<0.001 µm	▪ Water desalination

Increasing degree of fineness

Disruptor®

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 m^2 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.

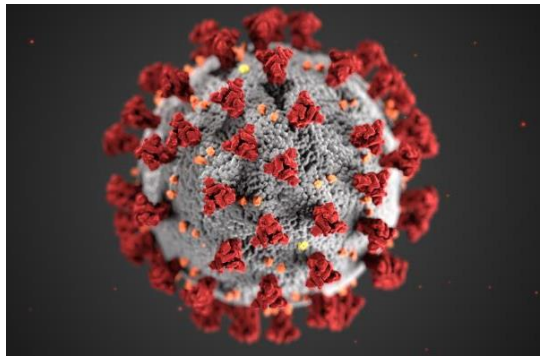
Ahlstrom-Munksjö quality testing of initial bacteria (RT), virus (MS2), and cyst (test method: TM-120)

Bacteria

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

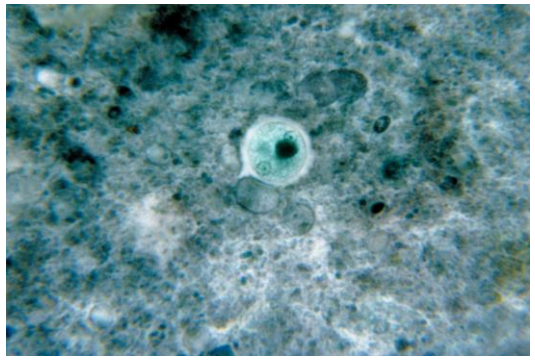
Virus

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



Cyst

- 3 microns 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

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

Biological Consulting Services of North Florida, Inc.

Single Layer 90 mm	MS-2 PLAQUE FORMING UNITS COUNTS PER MILLILITER												
	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	3.0×10^5	<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		<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 90 mm	MS2 PERCENT REDUCTION (%)												
	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	3.0×10^5	>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		>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/m^2 capacity or in total $2{,}36 \times 10^{12}$ (2,36 trillion) MS2 virus removed per m2 media at LRV 4.

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

Biological Consulting Services of North Florida, Inc.

Single Layer 90 mm	Day 1 Date:__02/14/2017___ EC 11229 PERCENT REDUCTION (%)													
	Influent	1 Liter Effluent	15 Liter Effluent	30 Liters Effluent	45 Liters Effluent	60 Liters Effluent	75 Liters Effluent	90 Liters Effluent	105 Liters Effluent	120 Liters Effluent	135 Liters Effluent	150 Liters Effluent	165 Liters Effluent	180 Liters Effluent
5283 Filter A__	6.0 x 105	>99.99993%	>99.99993%	>99.99993%	>99.99993%	>99.99993%	99,9991%	99,998%	99,996%	99,998%	99,992%	99,99 %	99,98 %	99,91 %
5283 Filter B__		>99.99993%	>99.99993%	>99.99993%	>99.99993%	99,9998%	99,999%	99,998%	99,996%	99,996%	99,995%	99,99 %	99,96 %	99,9%

Corresponding to ca. 7100 liters/m^2 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?

Personal Use

- Water bottle
- Backpack

Residential

- Top
- Countertop
- Under sink
- Pitcher
- Shower
- Dispenser
- Cooler
- Refrigerator
- Roof-top tank
- Whole house

Commercial

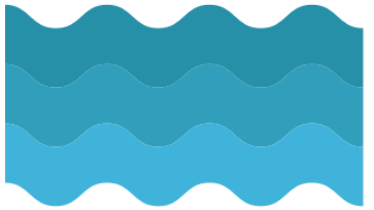
- Soft drink
- Coffee
- Tea
- Water
- Ice machines
- Buildings
- Hospitals

Industrial

- Cooling tower
- Manufacturing
- Water reuse
- Nuclear
- Aquaculture

Municipal

- Drinking water
- Waste water



Desalination

- Sea water
- Brackish water
- River water

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	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	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

BIOLOGICAL CONSULTING SERVICES
OF NORTH FLORIDA, INC.

March 16, 2016

Ahlstrom Filtration, LLC
122 W. Butler Street
Mt. Holly Springs PA 17065-0238

RE: Microbial filtration efficacy testing of the Ahlstrom Disruptor® based filter media

To whom it may concern,

BCS Laboratories has been conducting waterborne contaminants filtration efficacy studies on advanced filter media provided by Ahlstrom since 2012. The studies conducted include post production quality assurance, efficacy validation, and various custom tailored studies. Ahlstrom media with Disruptor® technology has repeatedly demonstrated effective bacterial, viral, and parasitic contaminant removals from drinking water as per the tested methodology. BCS Laboratory tests on production flat sheets of Disruptor® media demonstrated that the media removed >99.9999% of bacterial challenge, >99.99% of virus challenge, and >99.95% of parasitic cyst challenge from general test water (local municipal water) and reagent grade water as per the laboratory conditions of each test conducted.

Should you have any questions or concerns, please do not hesitate to contact me.

Best Regards,

George Lukasik, Ph.D.
Laboratory Director

BCS LABORATORIES, INC. - GAINESVILLE
4609 NW 6TH STREET, STE. A, GAINESVILLE, FLORIDA 32609
TEL. (352) 377-9272, FAX. (352) 377-5630
WWW.MICROBIOSERVICES.COM
FL DOH #E82924, ISO/IEC 17025:2005 L2422 (L-A-B), EPA# FL01147

Date: April 23, 2019

Subject: RoHS Compliance Laminated Disruptor® Grades:
Ahlstrom-Munksjö – Mt. Holly Springs, PA

Grades: 5281, 5282, 5283, 5283A, 5283N, 5284, 5287, 5288, 5289, 5290, 5292, 5293

Dear Customer:

Ahlstrom-Munksjö Filtration LLC's laminated Disruptor® materials are compliant under the European Union Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and its amendment 2015/863. Ahlstrom-Munksjö's Disruptor® grades do not intentionally contain any of the restricted items at or beyond the allowable limits, nor are any of the restricted items intentionally added during the manufacturing process.

RoHS Restricted Substances: Cadmium or cadmium compounds (<0.01%)
Hexavalent chromium (<0.1%)
Lead/lead compounds (<0.1%)
Mercury or mercury compounds (<0.1%)
Polybrominated biphenyls (<0.1%)
Polybrominated diphenyl ethers (0.1%)
Bis(2-ethylhexyl) phthalate (<0.1%)
Butyl benzyl phthalate (<0.1%)
Dibutyl phthalate (<0.1%)
Diisobutyl phthalate (<0.1%)

For any questions or concerns please contact regulatory.usmhs@ahlstrom-munksjo.com

Sincerely,

Sarah M. Evans

Sarah M. Evans
Product Development Specialist – Advanced Liquid Technologies

CC: Frank Cousart – Ahlstrom-Munksjö

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Chlorine Removal by Carbon Disruptor®

10.17.11

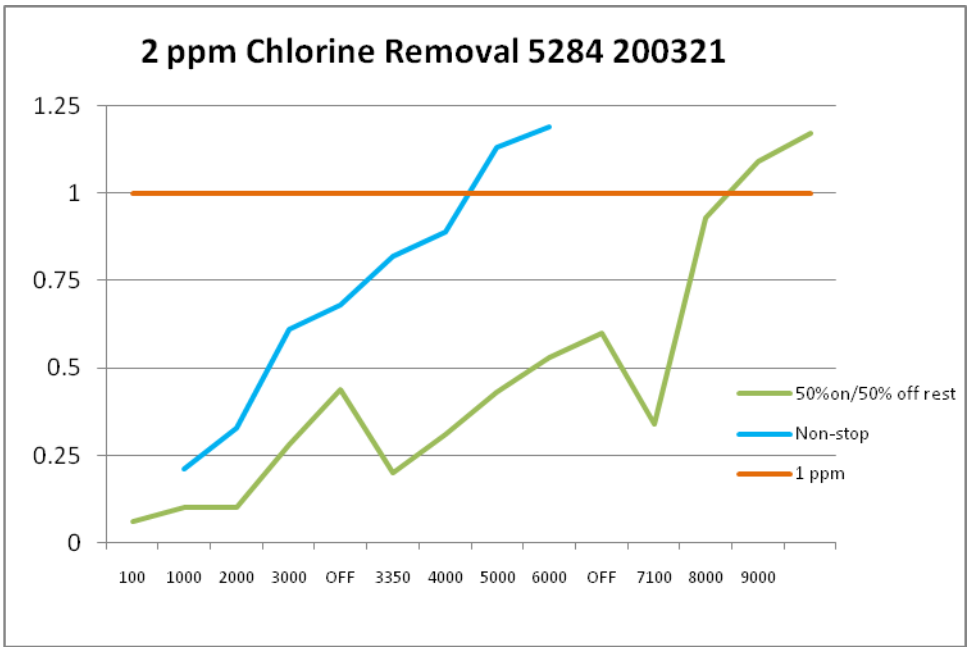
During production, a chlorine removal test is conducted on the base Disruptor® paper using a 2ppm chlorine challenge solution. The flow has been accelerated to 8.6 gallons/ft^2 and a 25-mm disc must pass 1 liter of challenge to 1 ppm or less to be acceptable. No extended life testing is performed.

NSF 42 describes a 50% on/ 50% off cycle for 16 hours followed by a 8 hour rest for chlorine testing. A 2ppm challenge is used and the effluent must also be reduced to 1 ppm or less. This on/off cycle allows for some recovery of the carbon and extends life. It more closely duplicates what a filter would see in a home environment. However in a continually on situation, the carbon is afforded no recovery time and life is shorter.

Testing was performed on 5284 Carbon Heat Seal Disruptor® 25-mm discs at the 50% on/50% off with an 8 hour rest and then with a continually on cycle. A 2ppm challenge at 1GPM/Ft^2 flow was used. The test was run in 4 hour cycles with an 8 hour rest period. A sample was collected every 1,000 ml.

In the non-stop test, the filter reaches 1 ppm breakthrough by 5,000 ml. This is equivalent to 354 gallons per ft^2. In the 50% on/50% off test, the filter reaches 1 ppm breakthrough by 9,000 ml or 638 gallons per ft^2. The cycling give the filter a 44.5% longer life.

There was a 54.5 % reduction in chlorine effluent after the first on/off cycle and a 43.3% reduction in chlorine effluent after the second on/off cycle.



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Thank you!

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