HYDRAsub® Technology

Maximum Performance…
Optimal Solution

Solutions You Need. Technologies You Trust.

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HYDRAsub®-ES MBR Technology

HYDRAsub® Overview	
Application	Membrane Bioreactor
Process Configuration	Submerged
Filtrate flow path	Outside to inside
Membrane material	PVDF
Membrane configuration	Vertical, Hollow fiber
Primary Cleaning Method	Air Scour

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HYDRAsub®-ES MBR Technology

Key Advantages

- High flux operation
- Low footprint requirement
- Simple operating process
- Durable construction

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High Flux Design

Design flux ~ 20 gfd (33 LMH)*

Minimized membrane area requirement

Lower capital cost of membrane	Lower Footprint Requirement	Lower aeration requirement

Minimized capital and operating cost

*Typical for municipal applications at 20 deg C or above

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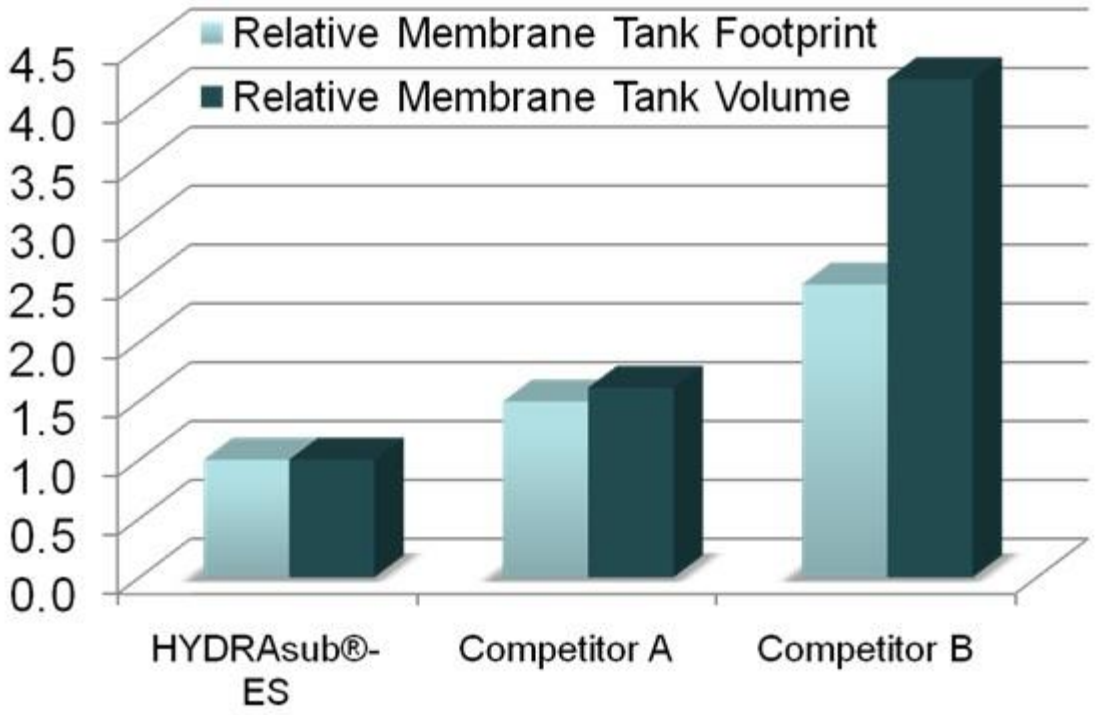
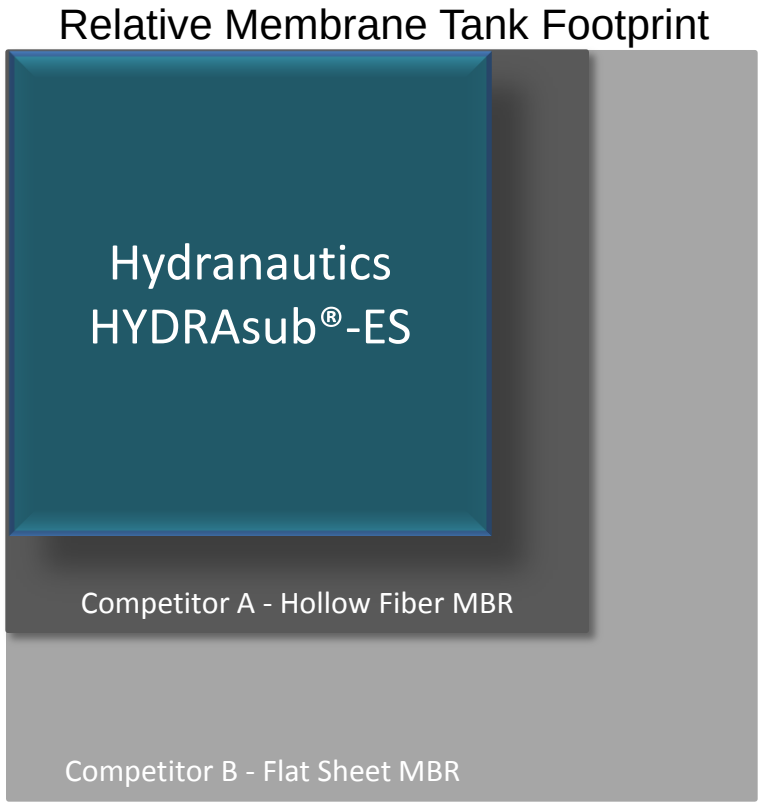
Low Footprint

- Design Basis: 10,000 m3/day with one train
- 8 HYDRAsub®-ES 1500 m^2 modules
- Competitor A – Hollow Fiber MBR
- Competitor B – Flat Sheet MBR





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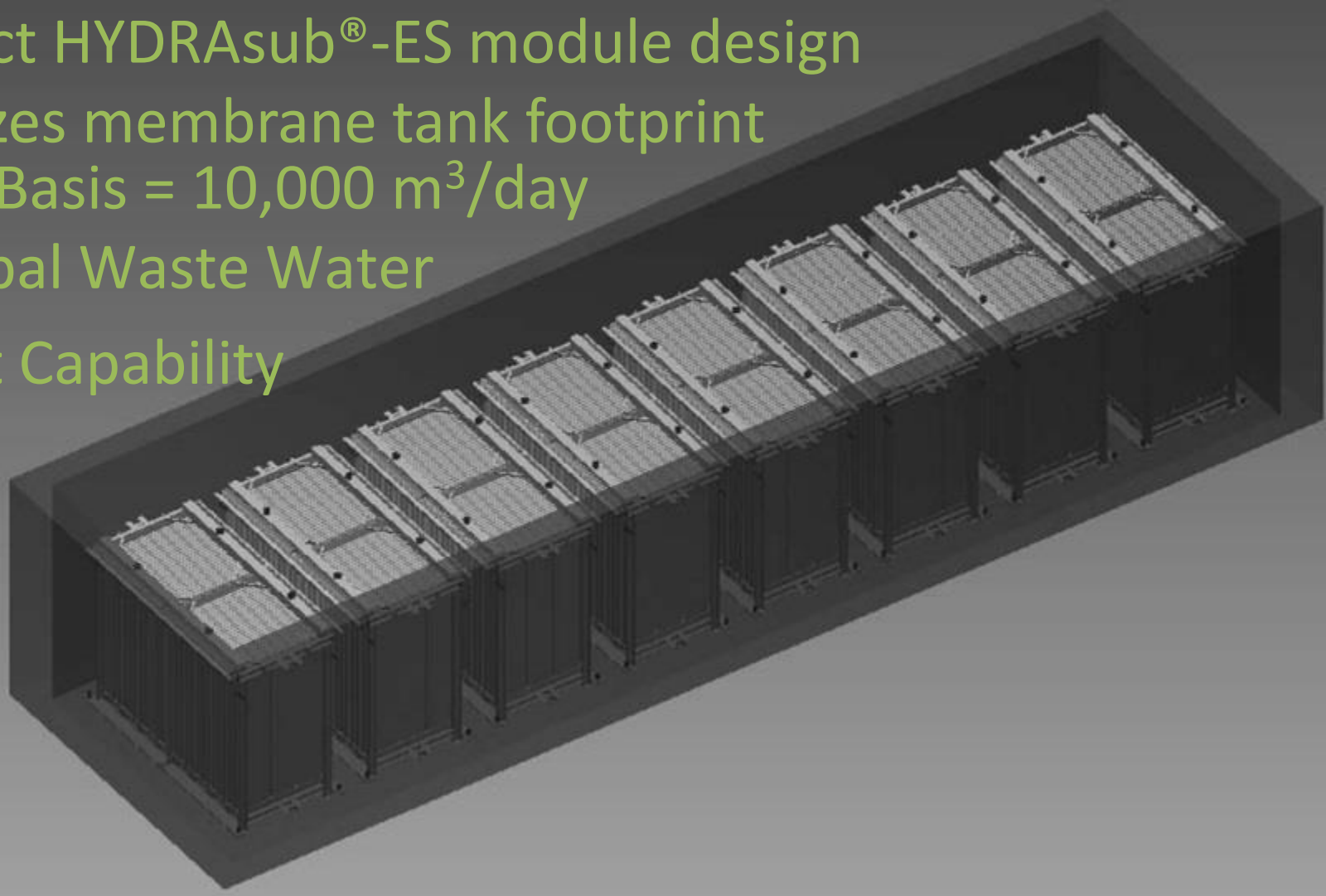
Low Footprint

- Compact HYDRAsub®-ES module design minimizes membrane tank footprint
- Design Basis = 10,000 m^3/day Municipal Waste Water
- Retrofit Capability



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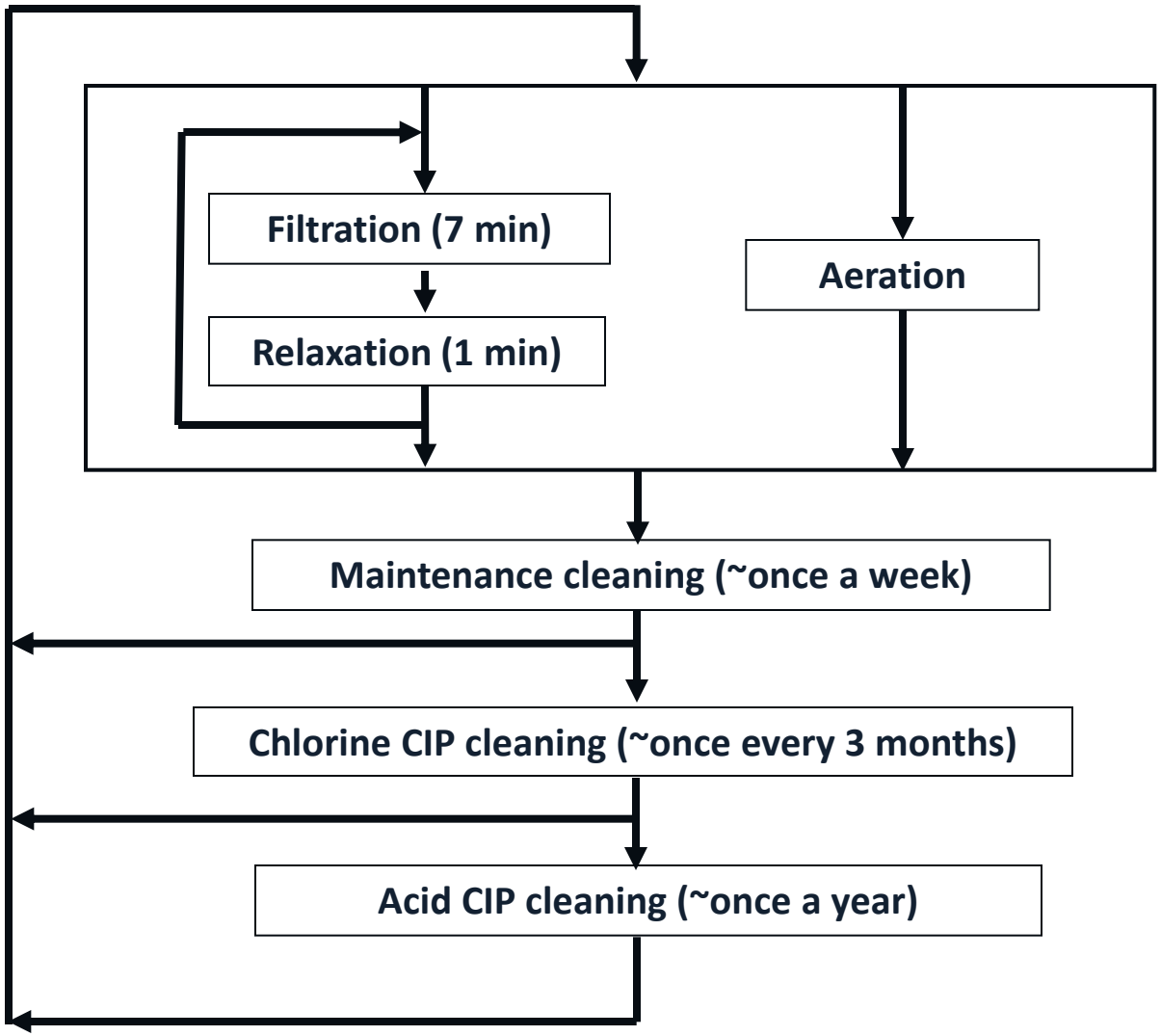
Simple Operating Process



- No backwash
- In sludge chemical cleanings
- No cycling valves
- Non-clogging air diffuser

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Durable Construction

- Manufacturing Plant – Yokohama, Japan
- Commissioned: October 2003
- No broken fibers to date

-> Ensures consistent filtrate quality

-> Minimizes downtime for repairs

= OpEx Reduction

-> Reduces fouling in RO system

-> Allows for higher RO design flux = CapEx Reduction

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HYDRAsub® MBR Applications

- Domestic Wastewater
  - Municipalities
  - Hotels, Apartment complexes
  - Grey Water
- Industrial Wastewater
  - Food Industry – Beer, Dairy, etc.
  - Automobile Production
  - Oil Refineries
  - Chemical Production
  - Potentially any wastewater with significant biological activity

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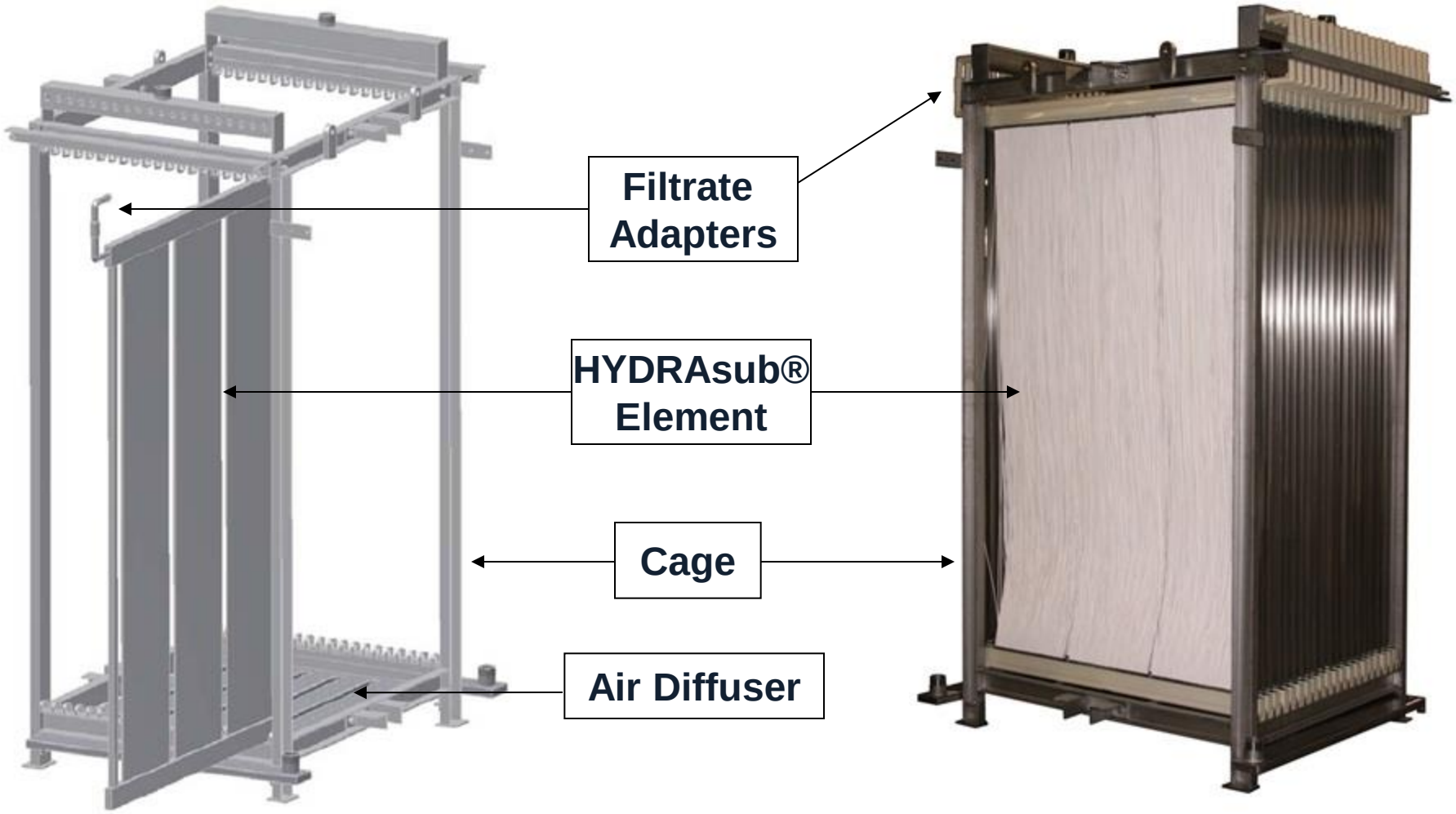
HYDRAsub®-ES MBR Technology



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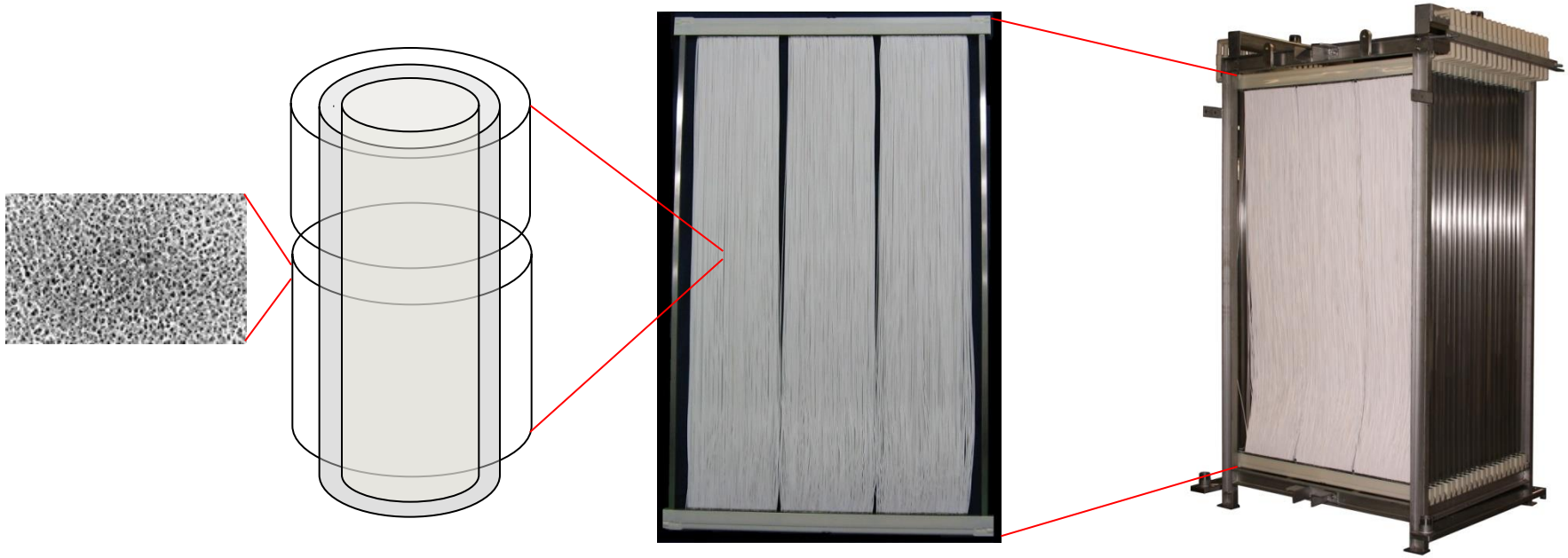
HYDRAsub®-ES MBR Specifications



HYDRAsub® Fiber	HYDRAsub® Element– 25 m^2	HYDRAsub® Module– 500 m^2
Polyvinylidene fluoride (PVDF)	25 m^2 active filtration area (15 m^2 element also available)	20 elements for total of 500 m^2 active filtration area
0.4 µm nominal Pore size	1250 mm (L) x 30 mm (W) x 2000 mm (H)	1560 mm (L) x 1240 mm (W) x 2460 mm (H)
2.8 mm Outer Diameter		

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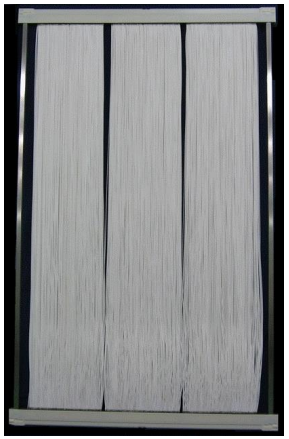
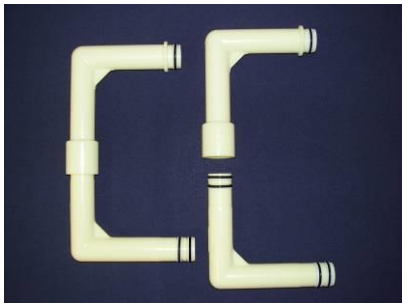
HYDRAsub® - Product Offering

 Module (HSM)		 Cages (HSC)*		 Elements (HSE)		 Adapters (HSA)
HSM75-ES	=	(1) HSC75-ES	+	(1 to 5) HSE15	+	(2 to 10) HSA25
HSM125-ES	=	(1) HSC125-ES	+	(1 to 5) HSE25	+	(2 to 10) HSA25
HSM250-ES	=	(1) HSC250-ES	+	(10) HSE25	+	(20) HSA25
HSM375-ES	=	(1) HSC375-ES	+	(15) HSE25	+	(30) HSA25
HSM500-ES	=	(1) HSC500-ES	+	(20) HSE25	+	(40) HSA25
HSM750-ES	=	(1) HSC750-ES	+	(30) HSE25	+	(60) HSA25
HSM1000-ES	=	(1) HSC1000-ES	+	(40) HSE25	+	(80) HSA25
HSM1500-ES	=	(1) HSC1500-ES	+	(60) HSE25	+	(120) HSA25

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*Cages include air diffusers

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HYDRAsub® - Small cages systems

Cages HSC125 with 25m2 elements:

Item	Cage	Elements	Membrane area (m^2)	Typical flow - Sewage (m^3/day)	Typical flow - Industrial (m^3/day)
HSM25-ES	1 HSC125-ES	1 HSE25	25	18	12
HSM50-ES	1 HSC125-ES	2 HSE25	50	36	24
HSM75-ES	1 HSC125-ES	3 HSE25	75	54	36
HSM100-ES	1 HSC125-ES	4 HSE25	100	72	48
HSM125-ES	1 HSC125-ES	5 HSE25	125	90	60

Cages HSC75 with 15m2 elements:

Item	Cage	Elements	Membrane area (m^2)	Typical flow - Sewage (m^3/day)	Typical flow - Industrial (m^3/day)
HSM15-ES15	1 HSC75-ES15	1 HSE15	15	11	7
HSM30-ES15	1 HSC75-ES15	2 HSE15	30	22	14
HSM45-ES15	1 HSC75-ES15	3 HSE15	45	32	22
HSM60-ES15	1 HSC75-ES15	4 HSE15	60	43	29
HSM75-ES15	1 HSC75-ES15	5 HSE15	75	54	36

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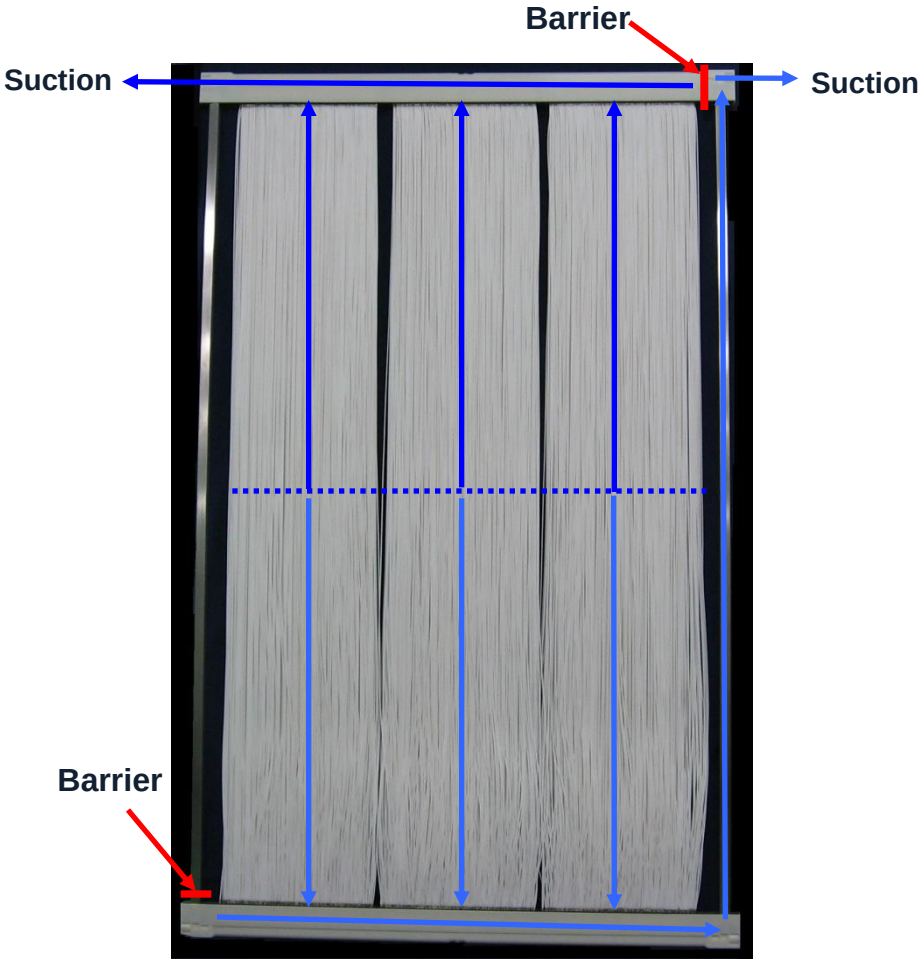
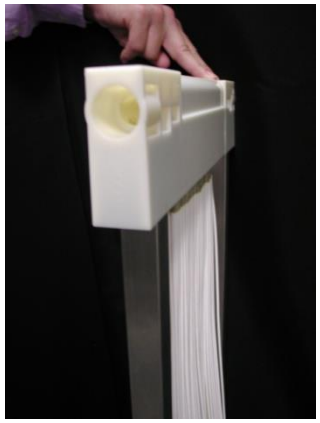
HYDRAsub® Element design



•By pulling suction from both sides and having barriers, the flow path is cut in half reducing the pressure drop across the membrane



•Side view of element with header opening

•Soft material is used at fiber-potting interface to reduce stress that can cause broken fibers

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HYDRAsub® Diffuser design

Simplified “Sheet Diffuser”

- Long lasting
- Non-clogging
- Minimum pressure drop
- Ensures uniform aeration

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HYDRAsub® Diffuser design

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Typical Operating Parameters

	Unit	Typical Value
Average Operating Flux[1,2]	gfd (LMH)	19.6 (33)
Peak Operating Flux[1,2]	gfd (LMH)	30 (51)
Transmembrane Pressure (TMP)	psi (kPa)	2-4 (13.8-27.6)
Mixed Liquor Suspended Solids (MLSS) concentration in membrane tank	mg/L	8,000-12,000
Filtrate Turbidity	NTU	< 0.2
Filtrate Total Coliform	cfu./100 mL	< 5
Filtrate TSS	mg/L	< 2
Filtrate SDI		< 3

[1]For municipal applications, at 20 deg C

[2]Piloting recommended to optimize flux for industrial applications

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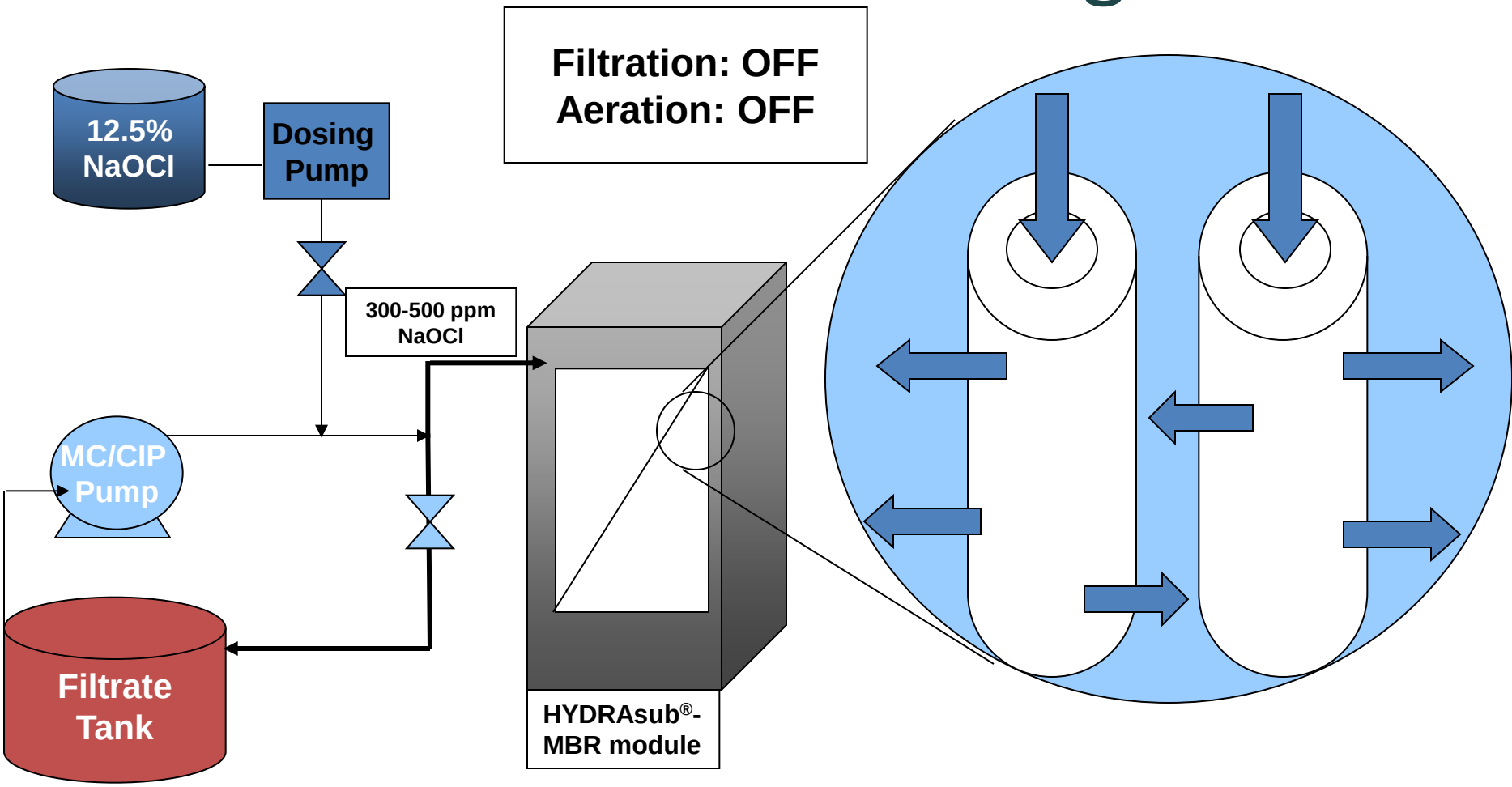
Maintenance Cleaning



Max. Backwash Pressure: 2 psig
Flux: 2.4 gfd (4 lmh)
Typical Frequency: 1/week

Procedure:
1. Backwash solution: 30 min

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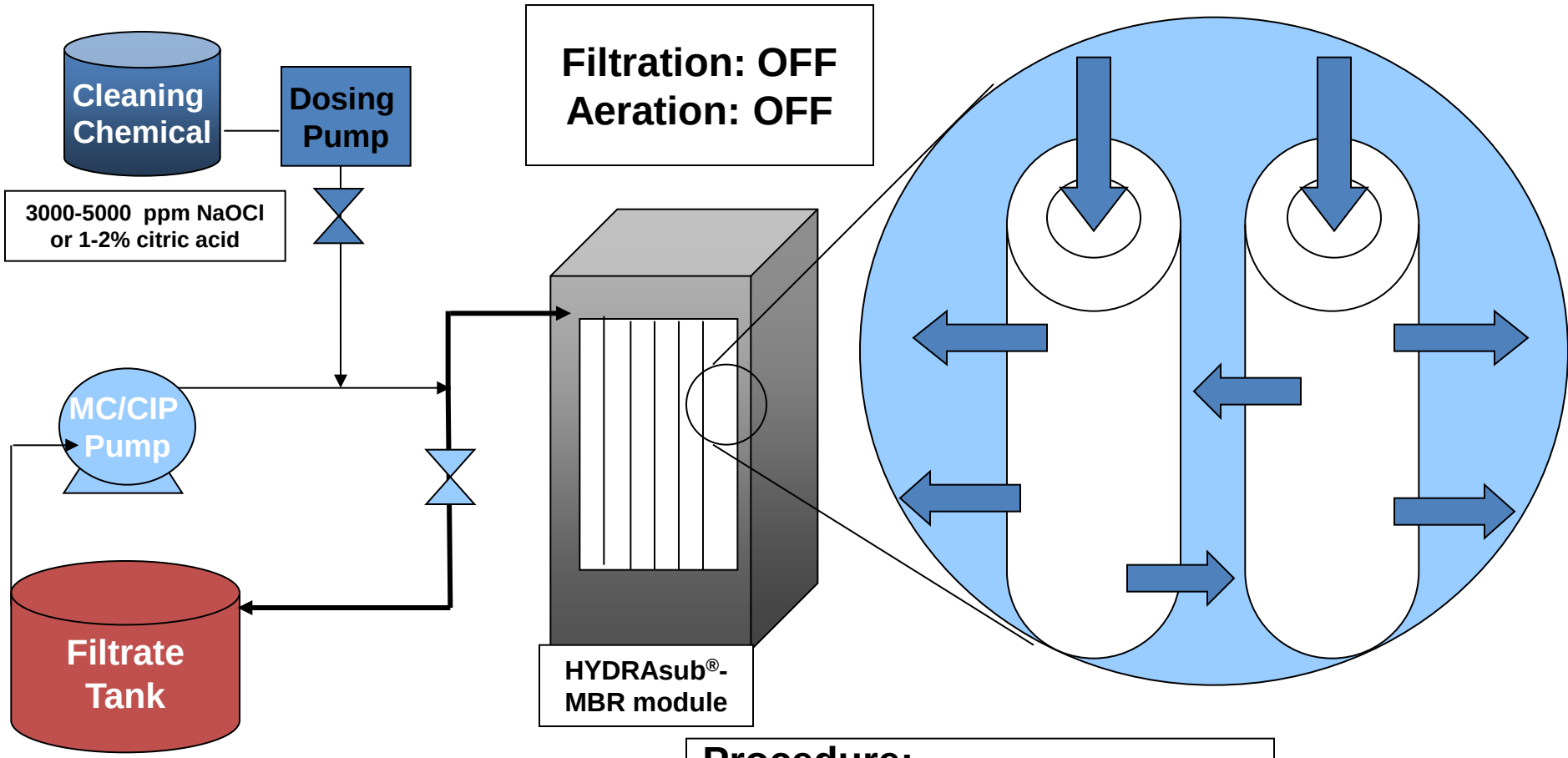
Clean-In-Place (CIP)



Max. Backwash Pressure: 2 psig
Flux: 2.4 gfd (4 lmh)
Typical Frequency: 1/3 months

Procedure:
1. Backwash solution: 30 min
2. Soak: 90 min
3. Air scour: 30 min

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HYDRAsub®-MBR Selected Installations

Country	FLOWRATE (m3/day)	FLOWRATE (MGD)	NO. of ELEMENTS	START-UP DATE	MODULE TYPE	MEMBRANE AREA (m2)	WATER TYPE	APPLICATION
Spain	900	0.238	3	2007	500	1,500	Sewage	Municipal
India	1,000	0.264	4	2008	375	1,500	Sewage	Municipal - Hotel
India	1,000	0.264	3	2008	500	1,500	Industrial waste water	Industrial - Automotive Industry
United States	230	0.061	2	2009	500	1,000	Industrial waste water	Industrial - Food and Beverage
India	1,445	0.382	8	2010	500	4,000	Industrial waste water	Industrial - Automotive Industry
Oman	150	0.040	1	2010	500	500	Sewage	Municipal
India	418	0.110	2	2011	375	750	Sewage	Municipal - Commercial complex
India	600	0.159	2	2012	375	750	Sewage	Industrial - Electronics industry
Malaysia	840	0.222	3	2012	500	1,500	Industrial waste water	Industrial - Automotive Industry
Singapore	45,333	11.976	36	2012	1,800	68,400	Sewage	Municipal
Bangladesh	500	0.132	2	2013	500	1,000	Industrial waste water	Industrial - Textile
Canada	527	0.139	2	2013	500	1,000	Sewage	Municipal
France	1,440	0.380	3	2013	750	2,250	Sewage	Municipal
India	390	0.103	2	2013	500	1,000	Industrial waste water	Industrial - Automotive Industry
North America	855	0.226	6	2013	250	1,500	Sewage	Municipal
Oman	250	0.066	2	2013	250	500	Sewage	Municipal - Replacement of Microdyn membranes
Saudi Arabia	200	0.053	2	2013	250	500	Industrial waste water	Industrial - Fat and oil plant
France	1,900	0.502	3	2014	1000	3,000	Sewage	Municipal
Mexico	25,920	6.847	24	2014	1500	36,000	Sewage	Reuse - Power Industry

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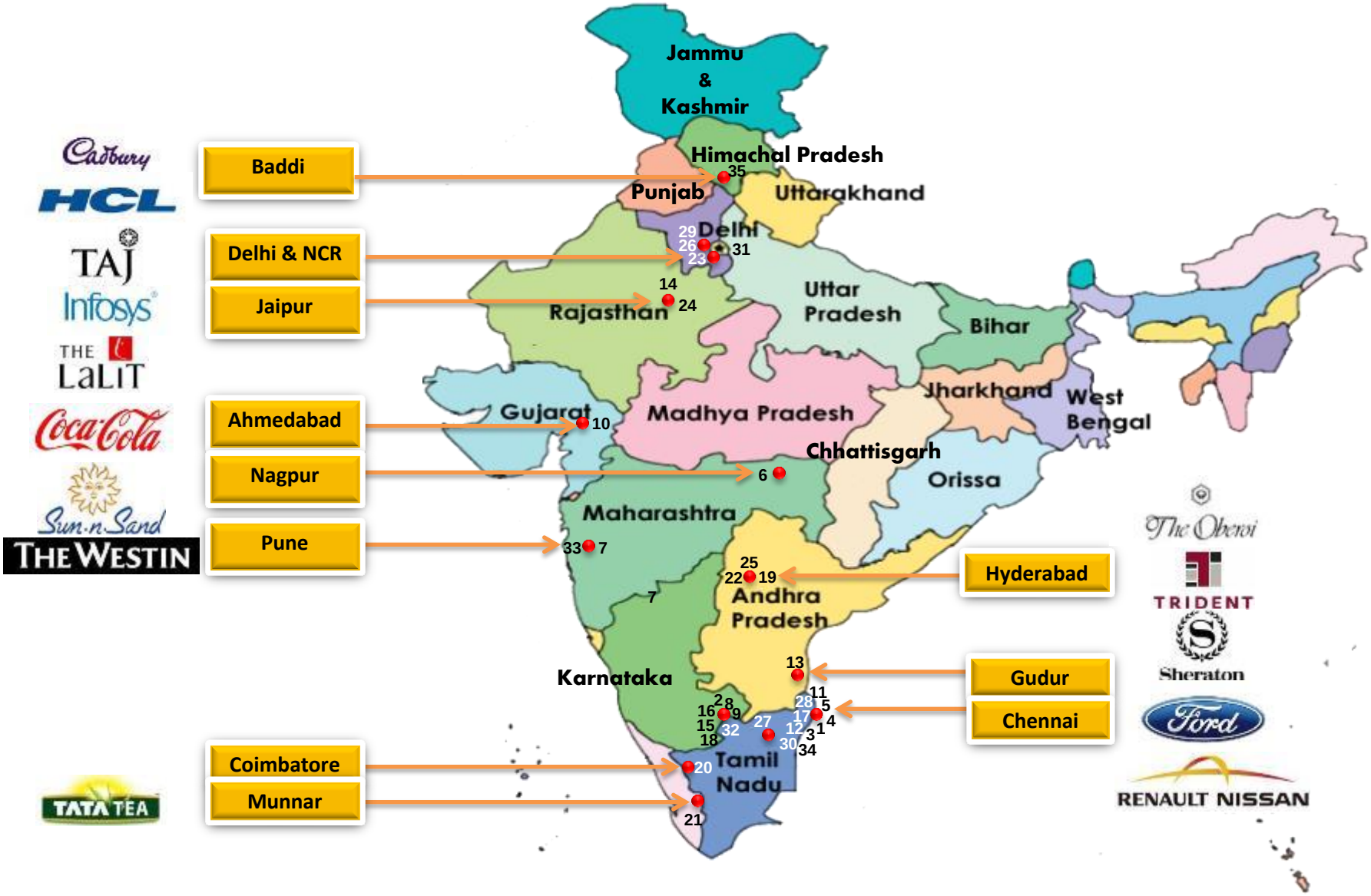
HYDRAsub®-MBR – References in India



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Municipal and Industrial Installations

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Jurong WRP, Singapore

- Treatment Type: BOD, Nitrogen, Phosphorus Removal
- Membrane Area: 68,400 m2 (36 HSM1800 modules)
- Capacity: 45,333 m3/day (12 MGD)
- Net Flux: 28 LMH
- Commissioned: February 2012

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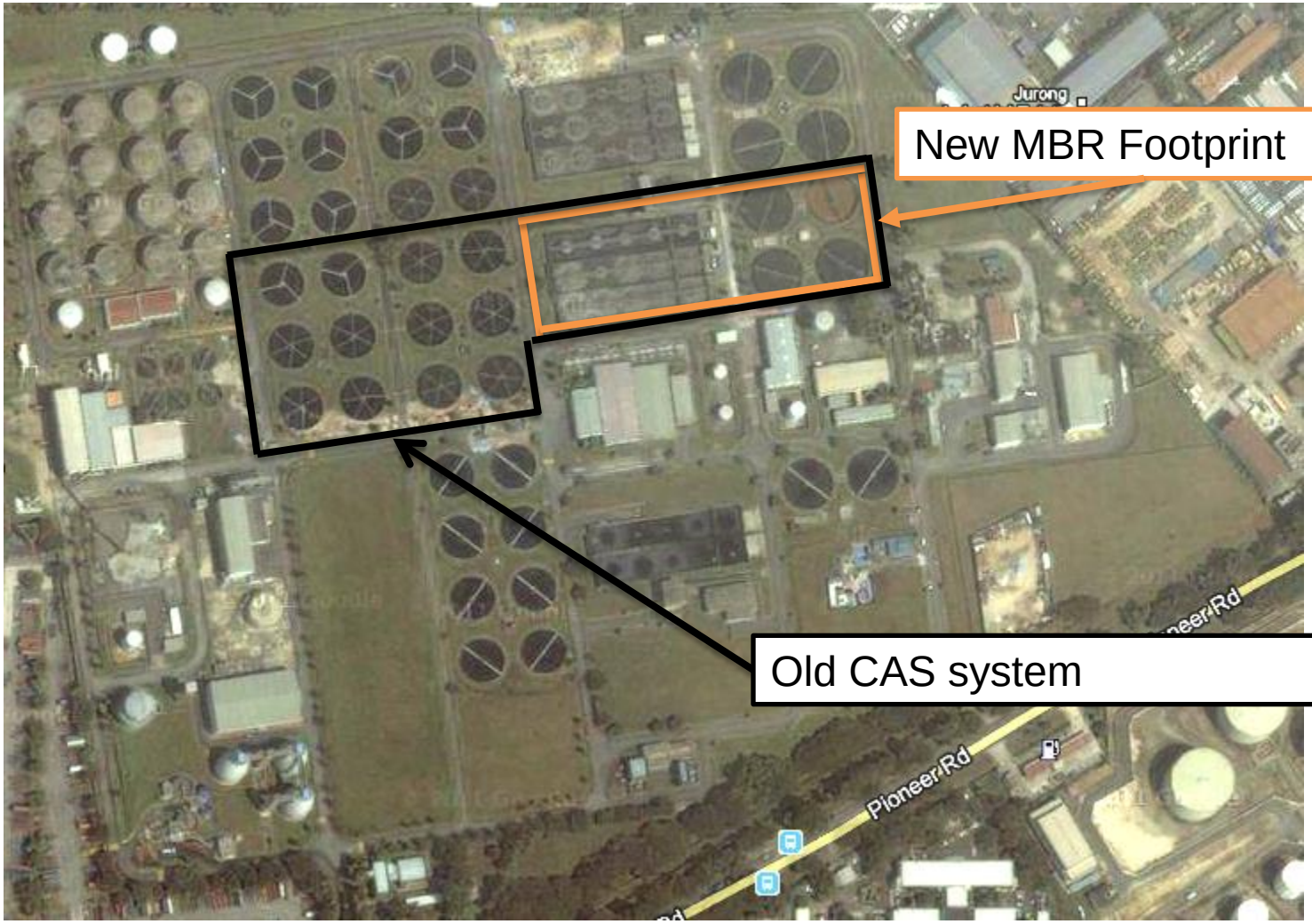
Jurong WRP Retrofit



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Stone Brewery MBR-RO, USA

- Treatment Type: BOD removal (aerobic treatment only)
- Membrane Area: 1,000 m2 (2 HSM500 modules)
- Capacity: 230 m3/day (42 gpm)
- MLSS Range: 8,000-12,000 mg/L in the membrane tank
- Commissioned: December 2009

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Pont du Casse WRP, France

- Treatment Type: BOD, Nitrogen Removal
- Membrane Area: 2,250 m2 (3 HSM750 modules)
- Capacity: 1,440 m3/day (264 gpm)
- Net Flux: 27 LMH
- Commissioned: September 2013

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Mexico City WRP, Mexico

- Treatment Type: BOD Removal
- Membrane Area: 36,000 m2 (24 HSM1500 modules)
- Capacity: 25,920 m3/day (6.85 MGD)
- Net Flux: 30 LMH
- Commissioned: February 2014

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HYDRAsub® MAX-ES Product Development

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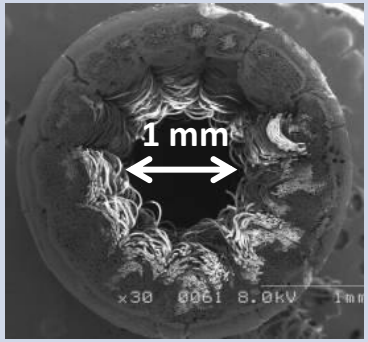
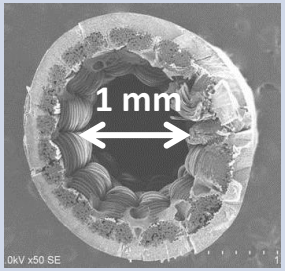
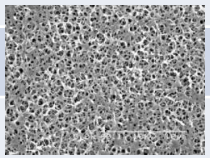
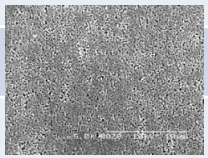
HYDRAsub® MAX-ES Product Development

		HSE25	HSE40
Surface Area	m2	25	40
Height	m	2.0	2.0
Width	m	1.25	1.25
Thickness	mm	30	30
Fiber Outer Diameter	mm	2.8	1.65
Pore Size	um	0.4	0.05
Fiber Inner Diameter	mm	Approx. 1.0 	Approx. 1.0 





- Same external dimensions – Direct replacement
- 40% increase in surface area
- Pore size reduction from MF to UF
- Also available in short element – HSE15 -> HSE24

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HYDRAsub® MAX-ES Product Development

		HSM1500-ES	HSM2400-ES
Surface area	m2	1500	2400
Element type	-	HSE25	HSE40
Number of Elements	-	60	60
Length	m	3.2	3.2
Width	m	1.6	1.6
Height	m	2.5	2.5
Module Packing Density	m2/m3	117	188
Production Capacity	m3/day	1200	1920
Air scour requirement	m3/hr	353-530	353-530
Normalized air scour requirement	m3/hr/m2	0.235-0.353	0.147-0.221

- Same cage design and dimensions
- 40% increase in packing density, production volume
- 40% reduction in normalized air scour requirement

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PVDF Hollow Fiber Membrane Comparative Test Results (Japan)

	System 1	System 2
Element type	HSA25	HSA40
Pore size (nominal)	0.4 µm	0.05 µm
Membrane surface area per element	25 m^2	40 m^2
Number of element	2 (and 4 dummies)	2
Membrane surface area per module	50 m^2	80 m^2

Parameters (mg/L)	Influent (Domestic Sewage)
BOD	105
COD_{Cr}	309
TOC	59.1
SS	141
T-N	31
T-P	3
COD_{Mn}	83.3

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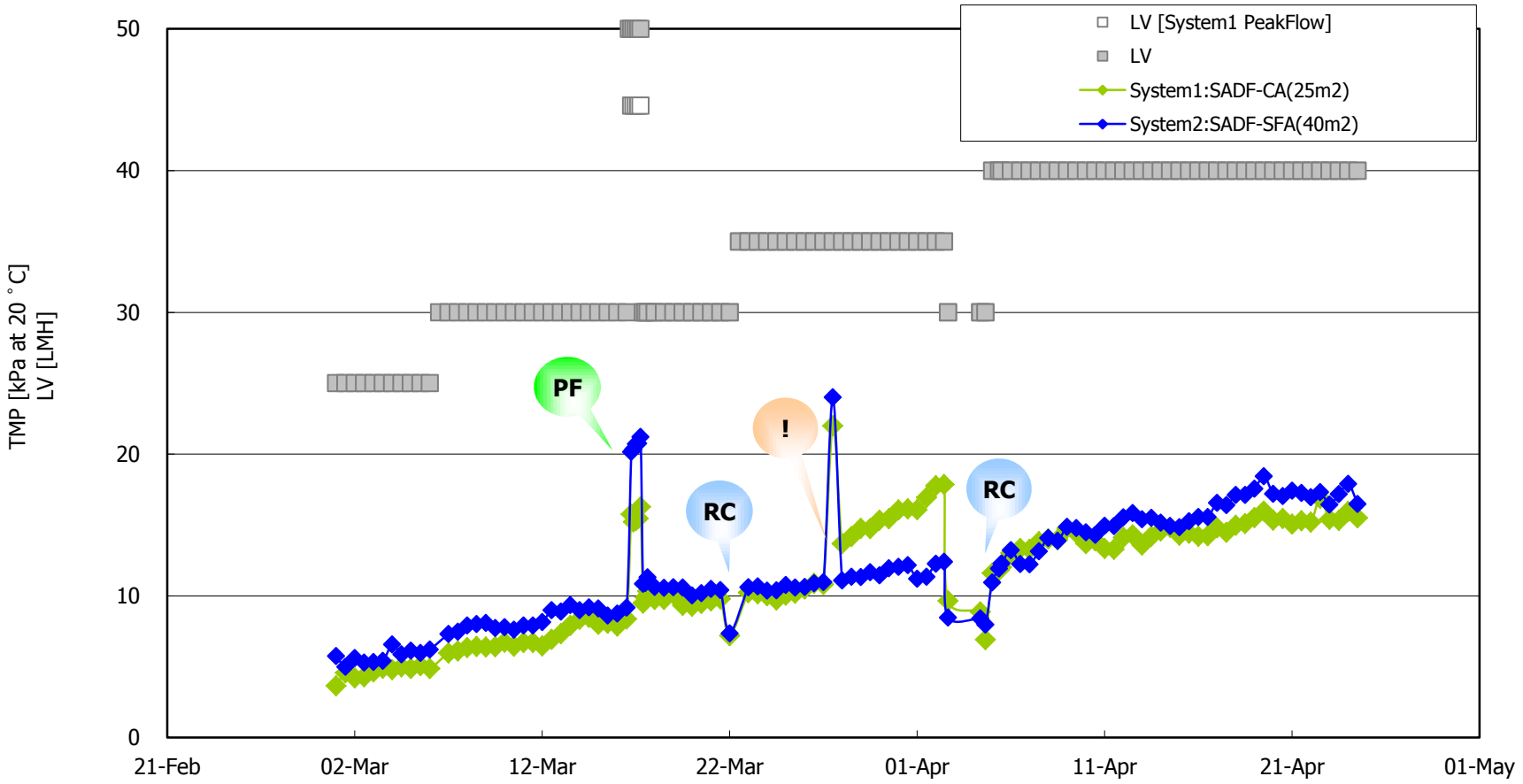
Pilot Test Conditions - Japan

	Run# 1	Peak Flow 1	Peak Flow 1
Object	System 1 & 2	System 1	System 2
Period	Feb 28-Apr 24	Mar 16-17	Mar 16-17
Net Operating Flux	17-40 LMH	45 LMH	50 LMH
Filtration on/off	7/1 min	7/1 min	7/1 min
Aeration volume	75 m/h	125 m/h	125 m/h
Maximum MLSS	10000 mg/L	10000 mg/L	10000 mg/L
Recovery cleaning	3000 mg/L NaOCl	3000 mg/L NaOCl	3000 mg/L NaOCl

Note: Maintenance cleaning was not executed.

Pilot test Japan - Trans-Membrane Pressure & Net Operating Flux



PF: Peak Flow
RC: Recovery Cleaning
!: Mechanical trouble (accidental blower shutdown)

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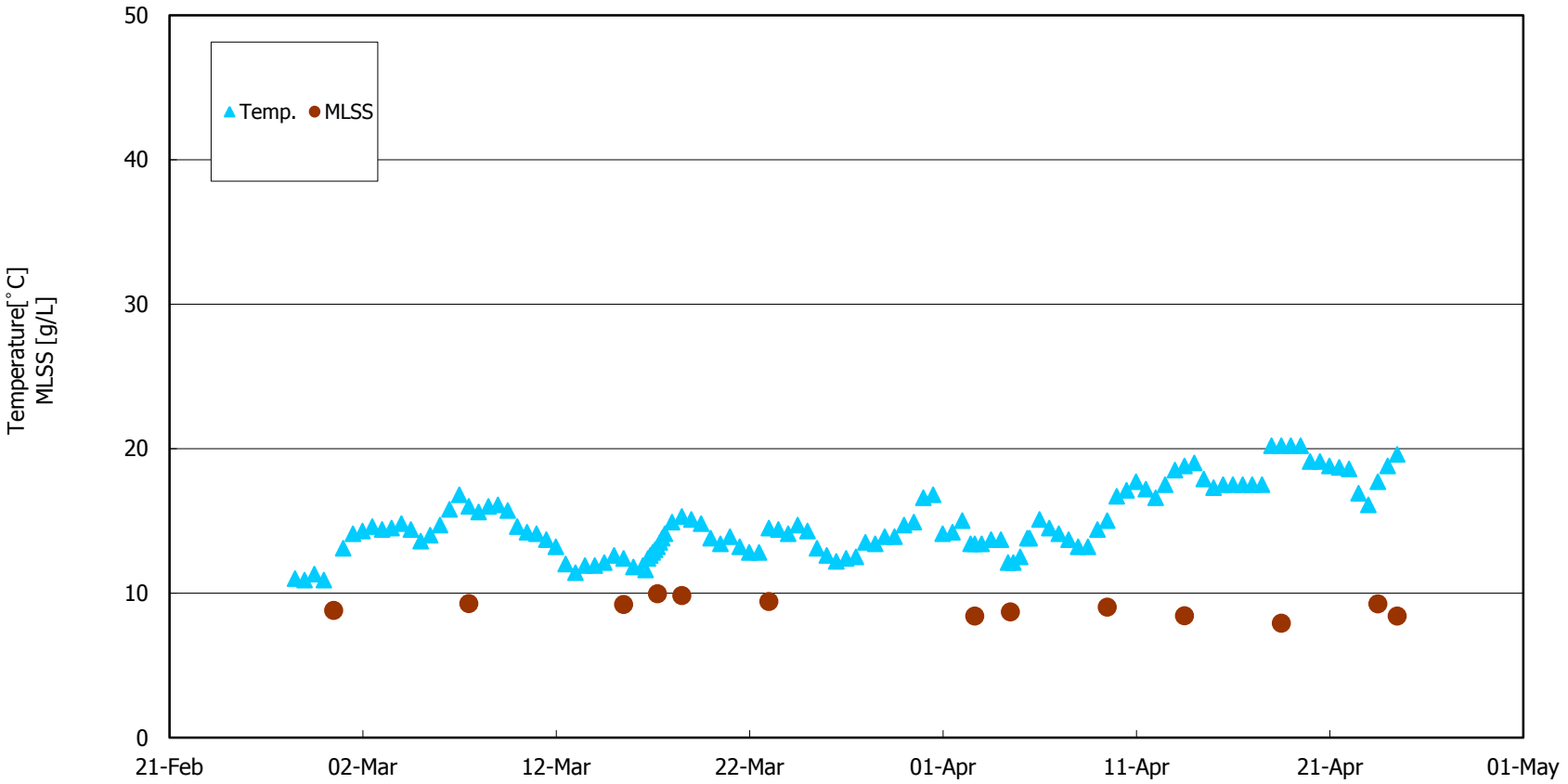
Pilot test Japan - Water Temperature & MLSS



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Pilot test in Singapore – Aug 2012~

	System 1
Element type	HSA40
Pore size (nominal)	0.05 µm
Membrane surface area per element	40 m^2
Number of element	8
Membrane surface area per module	320 m^2

Conditions	Run1
Net operating flux	0.6 - 0.84 m^3/m^2/day (25 - 35 LMH)
Filtration on/off	7/1 min
MLSS	Up to 10,000 mg/L
HRT	6 hours
Maintenance cleaning	Not executed
Recovery cleaning	3000 mg/L NaOCl

Parameters (mg/L)	Influent (Domestic Sewage)
BOD	226
COD_{Cr}	310
TOC	70.2
SS	124
T-N	45
T-P	12

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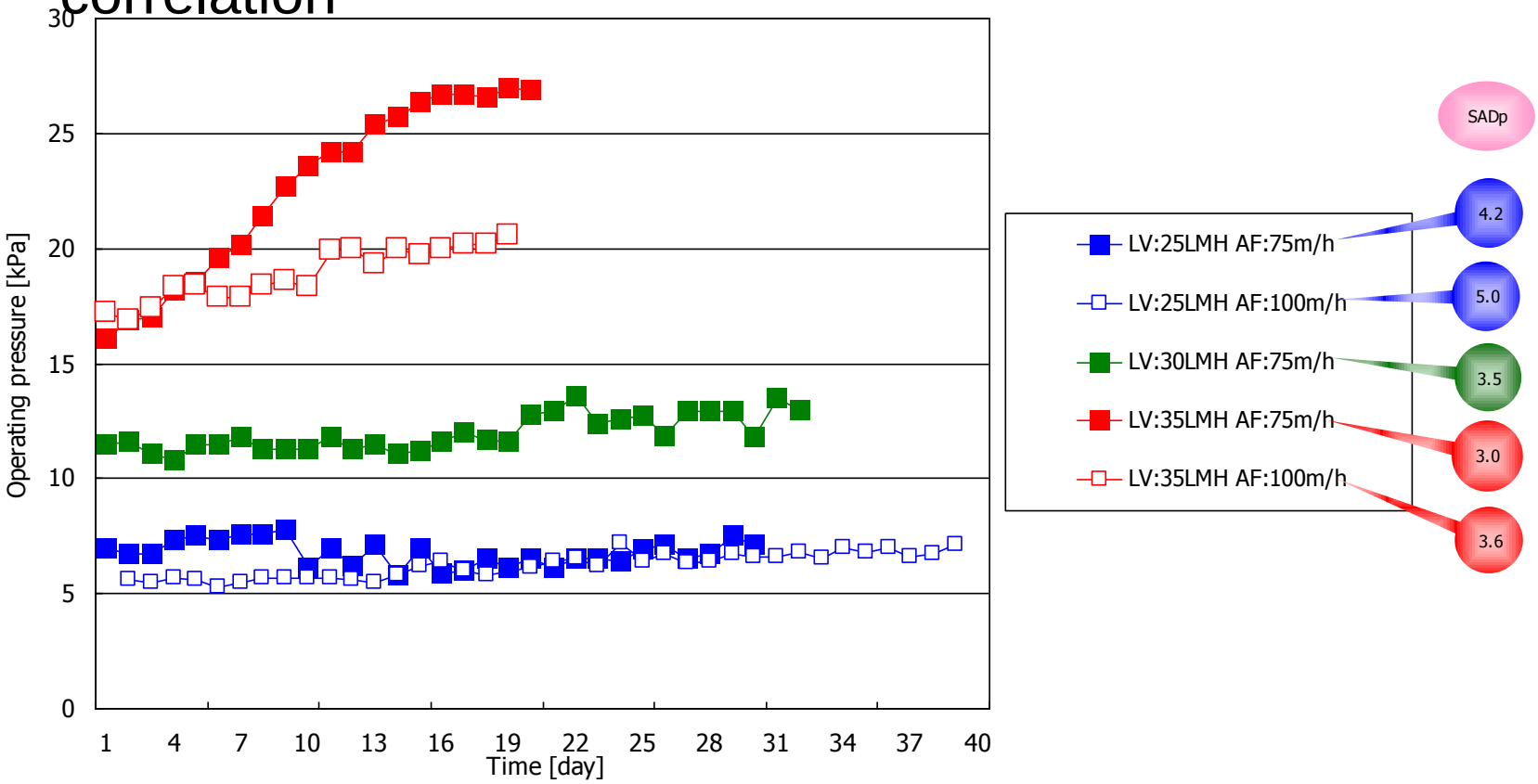
Pilot test in Singapore – Results

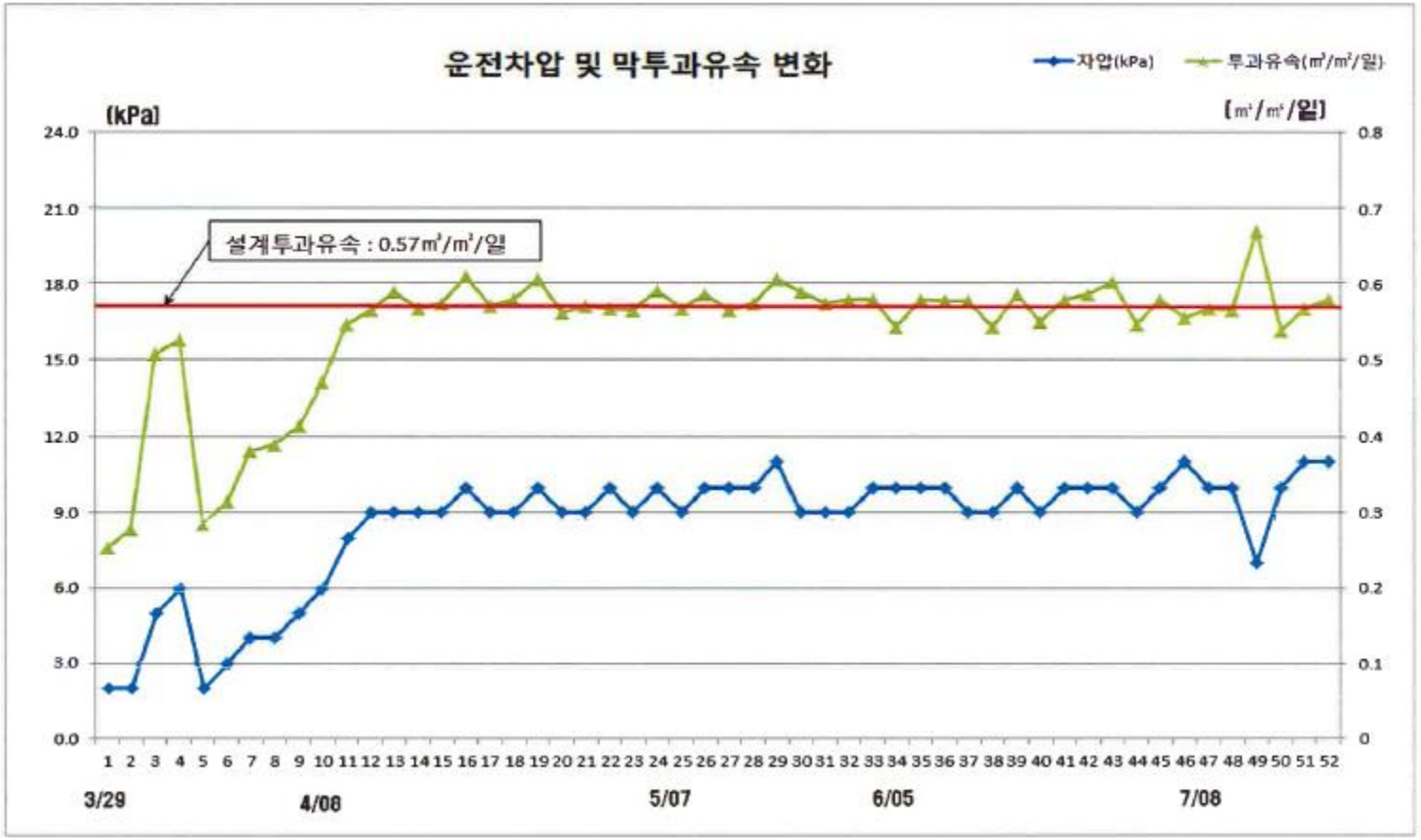
Permeate flux (LV), aeration flux (AF) and TMP correlation



Commercial plant data – South Korea

Module 800 m2 - Permeate Flux and TMP correlation

– Operation data: Mar.2013~Jul.2013



Membrane Scouring Air: 120 m^3/m^2/hour; MLSS: 2.890-4.800 mg/L; DO: 3.9-4.3 mg/L; HRT: 24.6 hours

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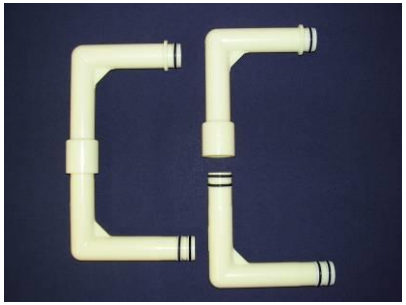
HYDRAsubMAX®-ES - Product Offering – HSE24/40

 Module (HSMMAX)		 Cages (HSC)*		 Elements (HSE)		 Adapters (HSA)
HSMM120-ES	=	(1) HSC120-ES	+	(1 to 5) HSE24	+	(2 to 10) HSA25
HSMM200-ES	=	(1) HSC200-ES	+	(1 to 5) HSE40	+	(2 to 10) HSA25
HSMM400-ES	=	(1) HSC400-ES	+	(10) HSE40	+	(20) HSA25
HSMM600-ES	=	(1) HSC600-ES	+	(15) HSE40	+	(30) HSA25
HSMM800-ES	=	(1) HSC800-ES	+	(20) HSE40	+	(40) HSA25
HSMM1200-ES	=	(1) HSC1200-ES	+	(30) HSE40	+	(60) HSA25
HSMM1600-ES	=	(1) HSC1600-ES	+	(40) HSE40	+	(80) HSA25
HSMM2400-ES	=	(1) HSC2400-ES	+	(60) HSE40	+	(120) HSA25

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*Cages include air diffusers

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HYDRAsub®-ES MBR Technology

- High operating flux
  - Reduced number of modules
  - Reduced footprint
- Simple operating process
- Low energy consumption
- Durable construction material

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Thank you

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