X-FLOW COMPETITIVE COMPARISON

27 MAY 2016

SEMINAR ON X-FLOW ULTRAFILTRATION MEMBRANES - ISTANBUL

X-FLOW FUNDAMENTALS

DRIVE SUPERIOR PERFORMANCE

PES DELIVERS SUPERIOR CHARACTERISTICS

SINGLE FIBERS FIT THE BEST

SMALL PORE SIZE, HIGH EFFLUENT QUALITY

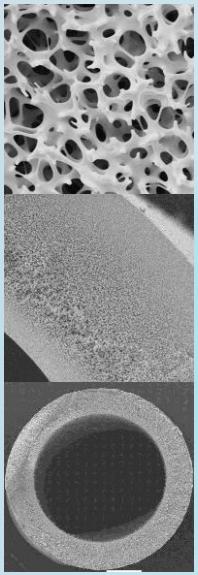
INSIDE-OUT IS RELIABLE

X-FLOW FUNDAMENTALS

PES DELIVERS SUPERIOR CHARACTERISTICS

PES as a base material delivers superior membrane characteristics over PVDF for hollow fibers:

1. **Best mechanical and thermal properties**
2. **Widest pH-range**
3. **Smaller pore size and narrower Pore Size Distribution**
4. **Higher MS2 Log Removal Value (LRV)**

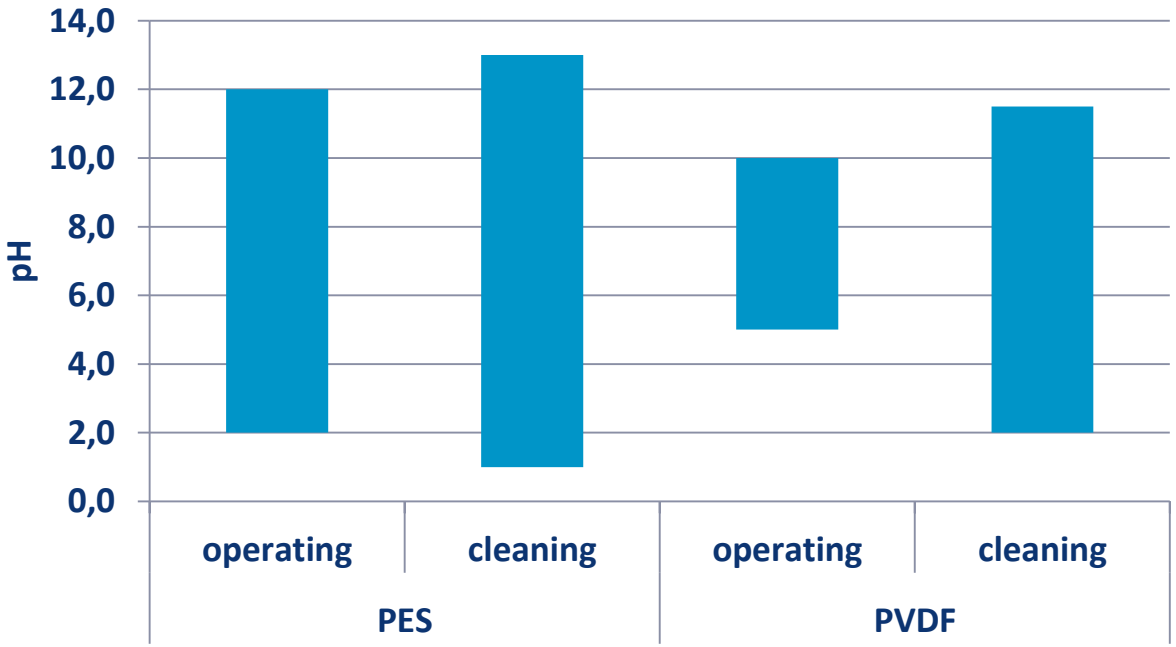


1. BEST MECHANICAL AND THERMAL PROPERTIES

Source: Ensinger-online.com

Mechanical properties	Parameter	PVDF Value	PES Value	Unit	Key takeaway
Tensile strength	50mm/min	62	89	MPa	 **Higher tensile strength means more resilient material**
Flexural strength	2mm/min, 10N	77	122	MPa	 **Higher flexural strength means less creep and a longer lifetime**
Impact strength	Max. 7.5J	150	175	kJ/m^2	 **Higher impact strength means more resistant to sudden process changes, e.g. water hammer**
Thermal expansion	23-100°C, long.	18	6	$10^{-5}\ K^{-1}$	 **Thermal expansion results in increased pore size, thus decreased retention**

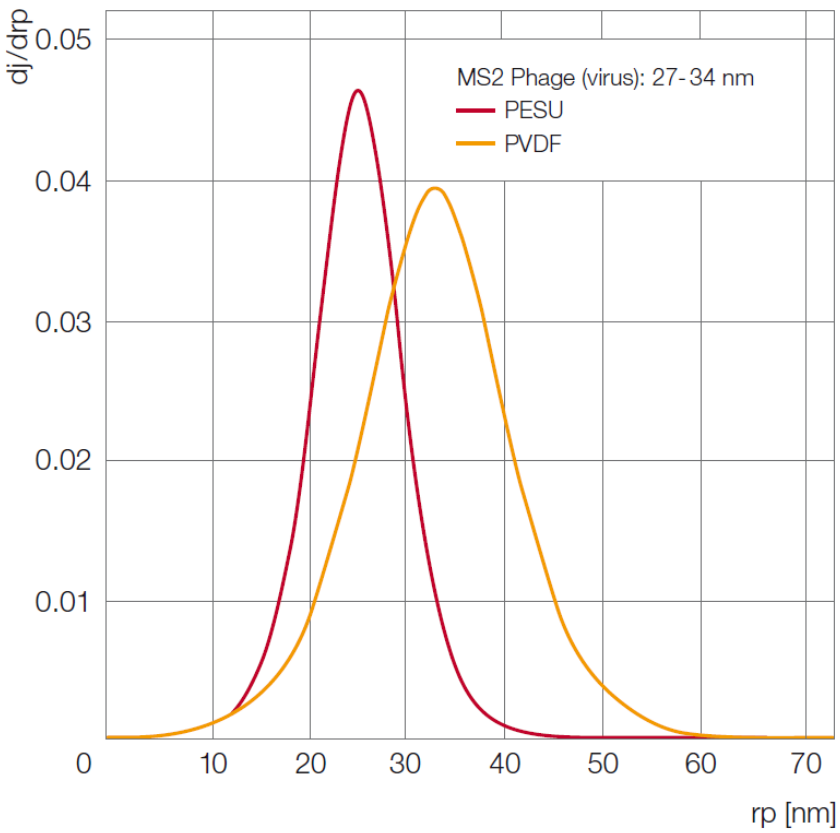
2. WIDEST PH-RANGE



Key takeaway

PES has a wider pH-range. This allows for cleaning at a higher pH-value. Cleaning becomes more effective at higher pH-values. This is specifically relevant for emergency recovery cleaning of heavily fouled membranes.

3. SMALLER PORE SIZE AND NARROWER PSD



Pore size distribution of two commercial membranes with nominal pore size “20 nm” **(source: Ultrapure Water, (4 /2010), 33 ff)**

Key takeaway

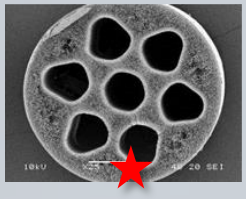
Smaller pore size means higher effluent quality. A narrower Pore Size Distribution (PSD) means more pores per m2, means higher permeability, means lower energy consumption

X-FLOW FUNDAMENTALS

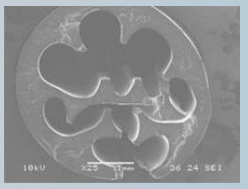
SINGLE FIBERS FIT THE BEST

A single fiber has the best geometry for membrane fibers:

1. **Highest burst and collapse pressure**
2. **100% integrity**
3. **Effective membrane cleaning**

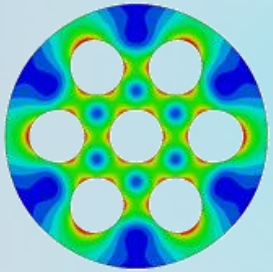


Structural weakspots



Complete collapse

Even tension distribution



potential collapse area

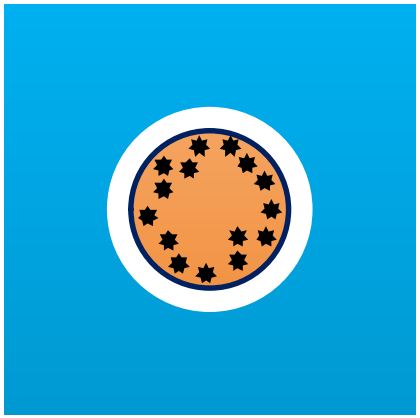
1. HIGHEST BURST AND COLLAPSE PRESSURE

X-Flow fiber collapse pressure: 15 bar
Multibore collapse pressure: 11 bar

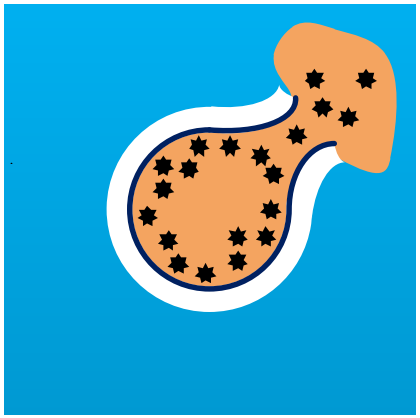
Key takeaway

The critical mechanical properties of a membrane are the burst and collapse pressure. Collapse pressure is challenged during backwash, being the most critical load on a membrane. This movie proves that a single fiber is much stronger, since it only collapses at considerable higher pressure.

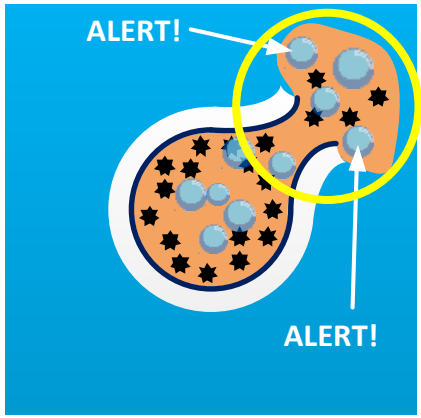
2. 100% INTEGRITY FOR SINGLE FIBER



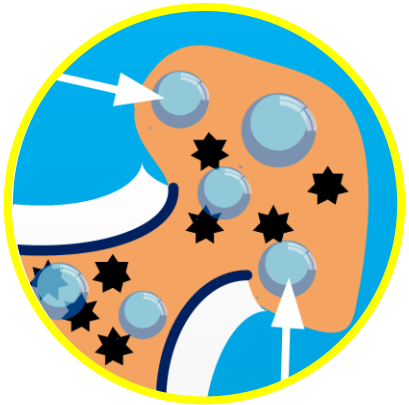
OPERATION

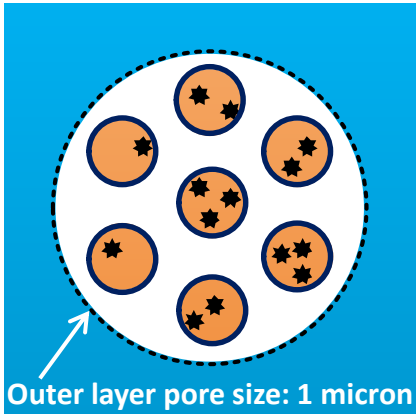


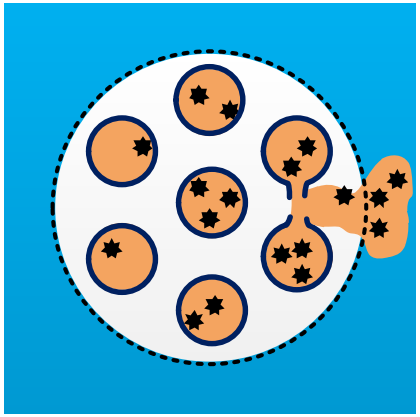
FIBER BREAKAGE

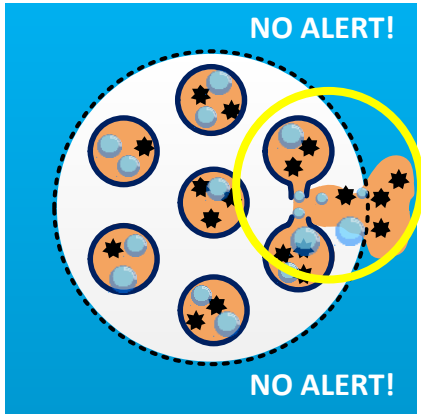


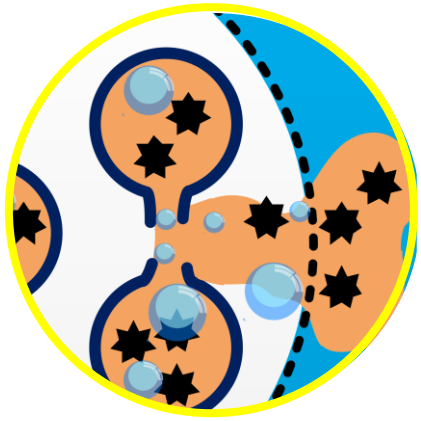
AIR INTEGRITY TEST











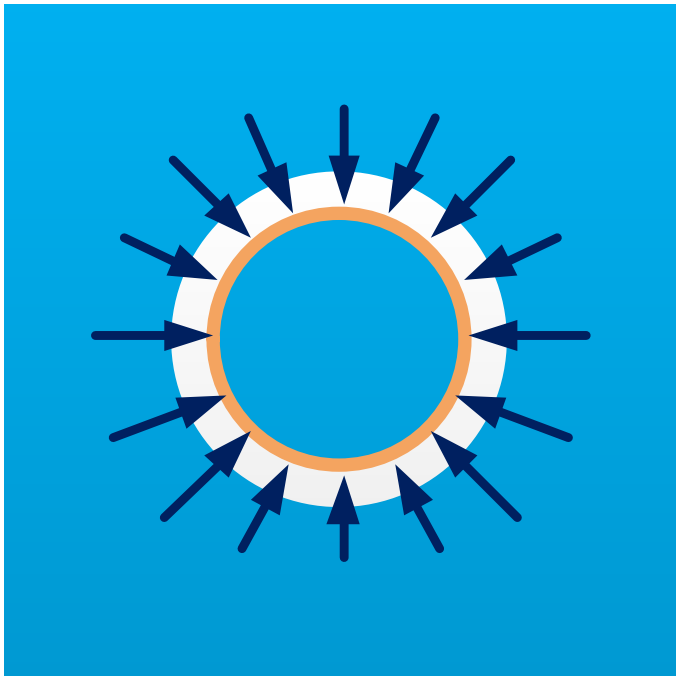
Key takeaway

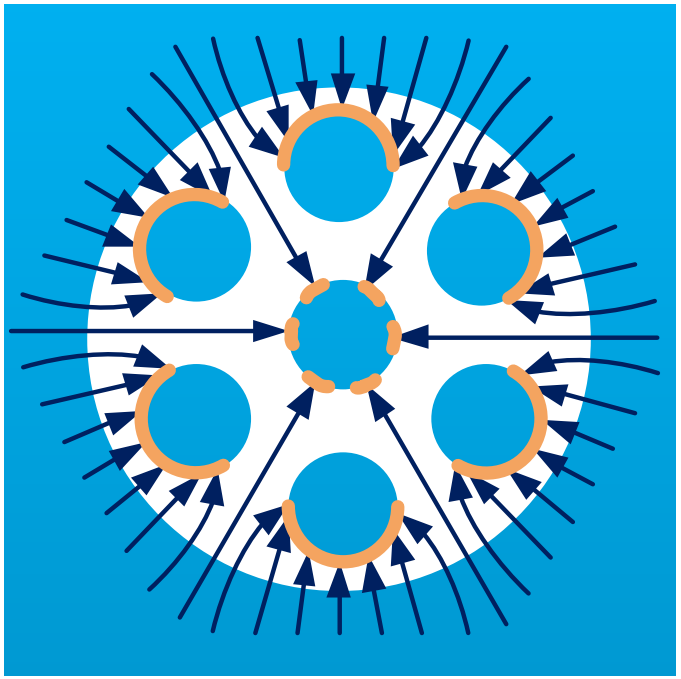
Multibore cannot guarantee a retention of sub-micron particles, as on the outside of a multibore a support layer with micron size pores is present. Viruses and even some bacteria will pass the micron pores in the support layer, not preferable for drinker water applications.

3. EFFECTIVE MEMBRANE CLEANING

BACKWASH FLOW

EFFECTIVE BACKWASH AREA





Key takeaway

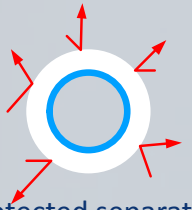
In a single fiber geometry, the backwash flow is equally distributed of the active membrane surface area. In a multibore fiber, preference flows will occur which will result in unequal backwash flow distribution. In turn, this results in ineffective or incomplete membrane cleaning.

X-FLOW FUNDAMENTALS

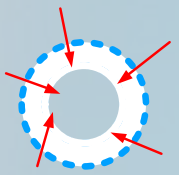
INSIDE-OUT IS RELIABLE

With inside-out filtration, the active membrane surface is optimally protected:

1. **Gentle cleaning without the use of air-scour**
2. **No risk of abrasive wear of fibers during operation**
3. **Separating layer fully isolated from outside influences**



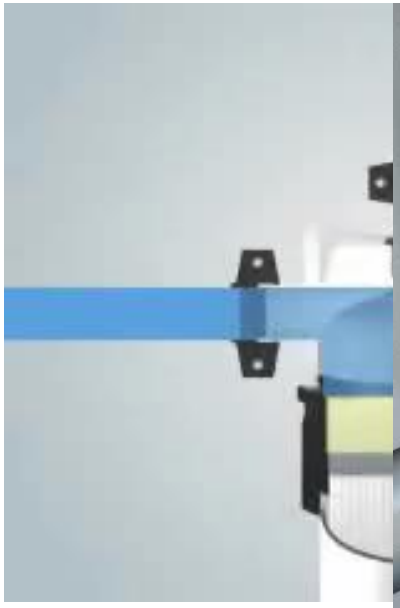
Protected separating layer on inside

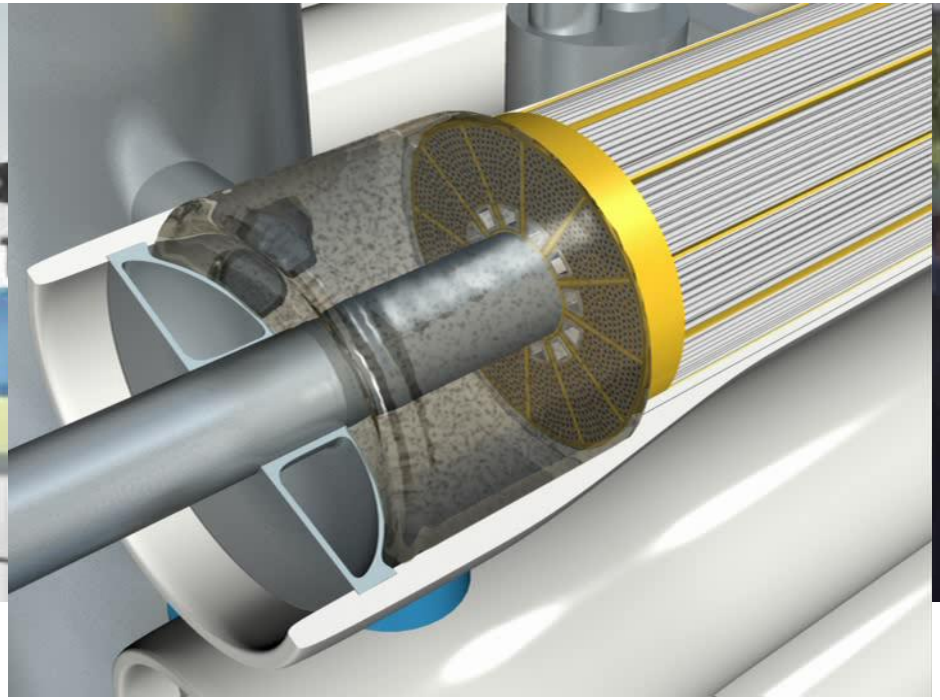


Unprotected separating layer on outside

Abrasive wear on unprotected separating layer on outside

1. GENTLE CLEANING WITHOUT USE OF AIR



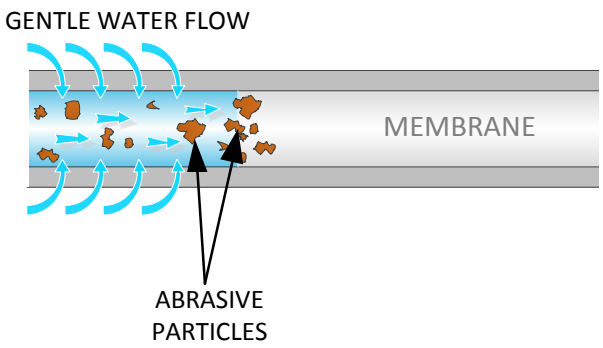


Key takeaway

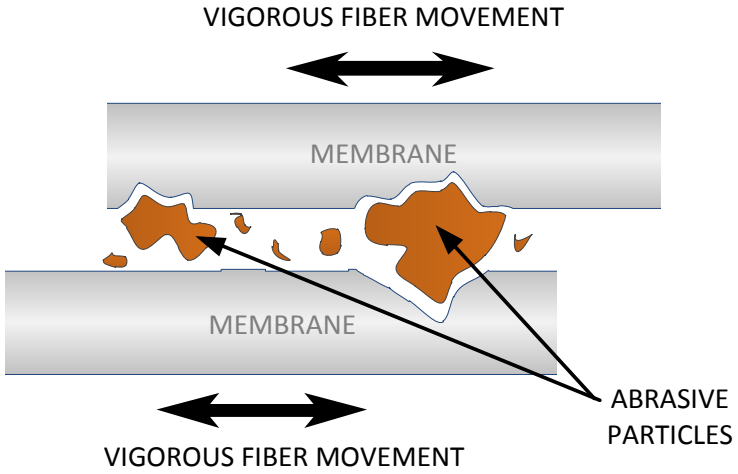
Outside/in make use of air scrubbing or air scouring to clean the membranes. The membranes are vigorously shaken to remove debris, herewith challenging the membranes physically. Moreover, the use of air to clean membranes increases operational expenses, and backwash cannot be replaced by this.

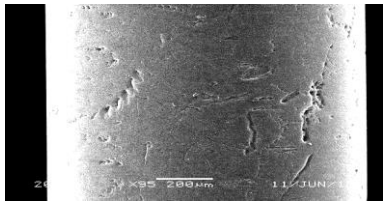
2. NO RISK OF ABRASIVE WEAR

GENTLE OUTSIDE/IN BACKWASH



VIGOROUS AIR SCRUBBING





Key takeaway

With pressurized, inside-out membrane modules, a gentle backwash flow pushes the debris away from the membrane wall to exit the element. In outside/in systems, air scrubbing is used to vigorously shake the fibers, with a high probability of abrasive wear between fibers.

QUESTIONS?