



Pall Corporation

Protecting What Matters, Every Day



June 14<sup>th</sup>, 2018  
Danish Dairy Association

## Examples of Crossflow MF Solutions for Dairy Industry

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PALL is part of DANAHER since 2015





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## Danaher's Reporting Segments



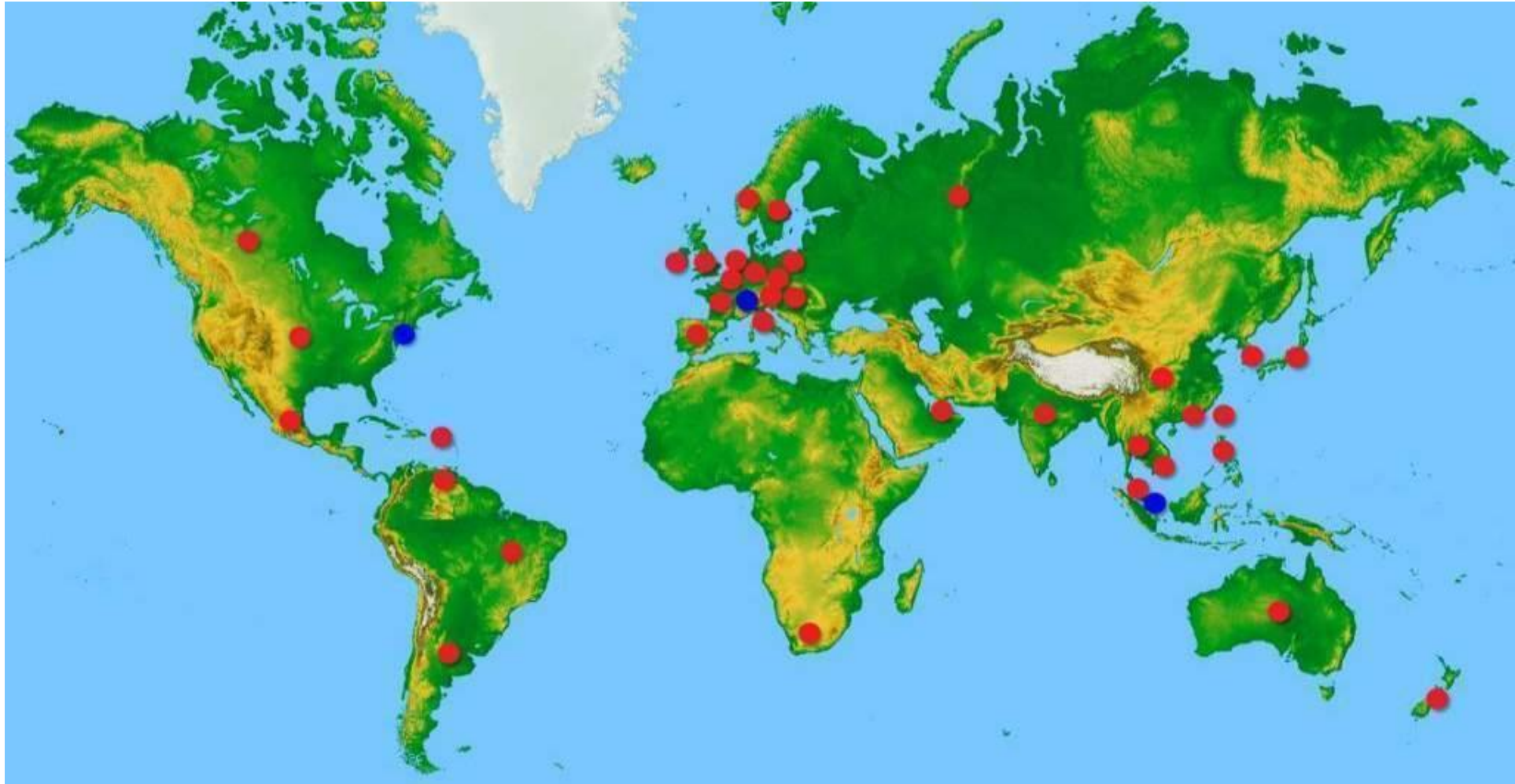
All financial metrics shown reflect FY 2017 revenues

Multi-industry science & technology portfolio provides competitive advantages



Pall Corporation

## Pall has a Strong Channel with Great Global Reach



## Markets

- Beer



- Wine & Spirits



- Food & Dairy



- Alcohol Free Beverages

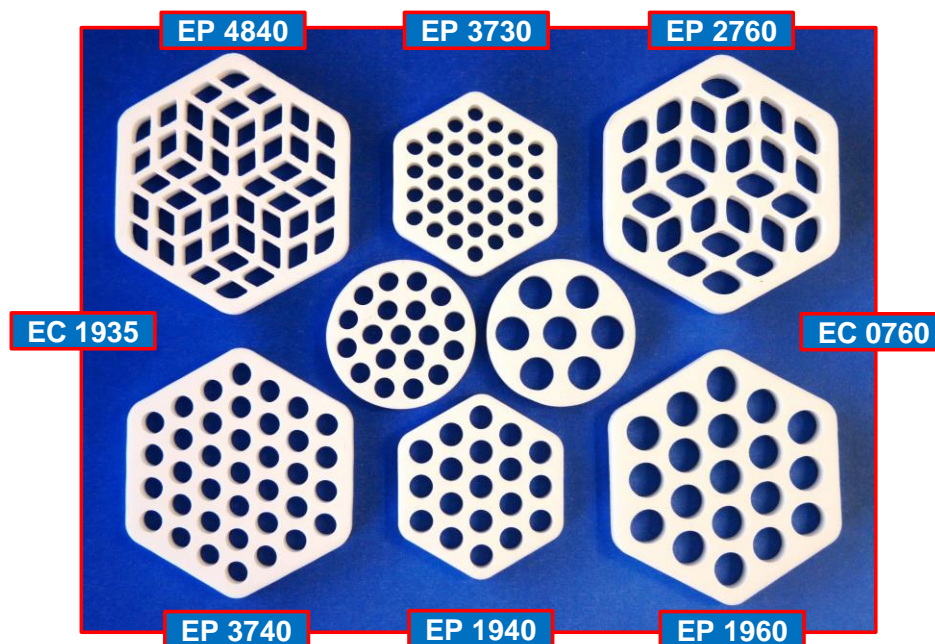


- Laboratory QC & Food Safety

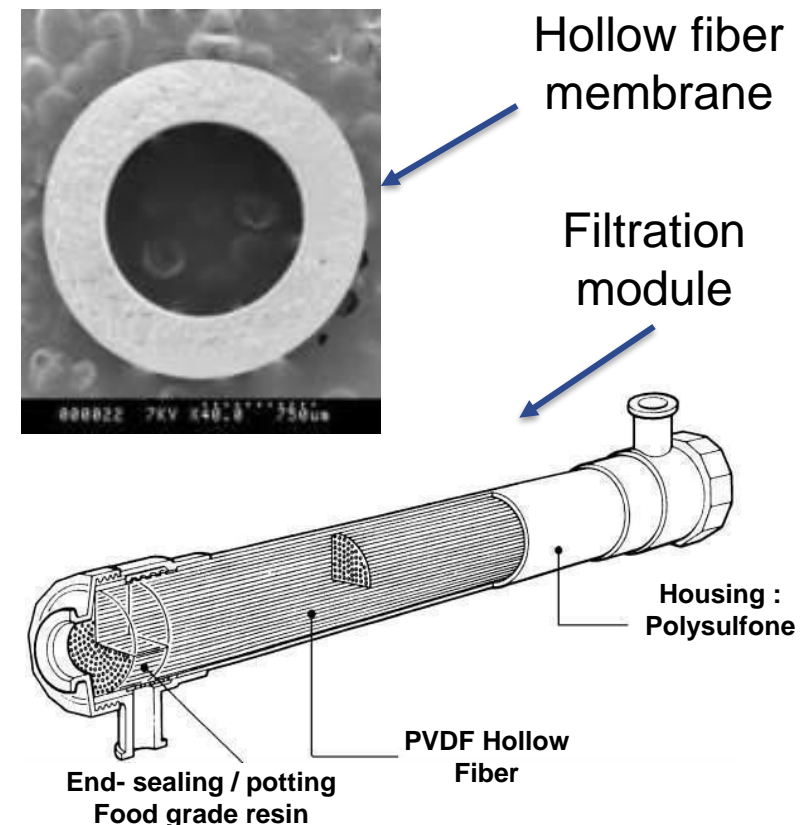


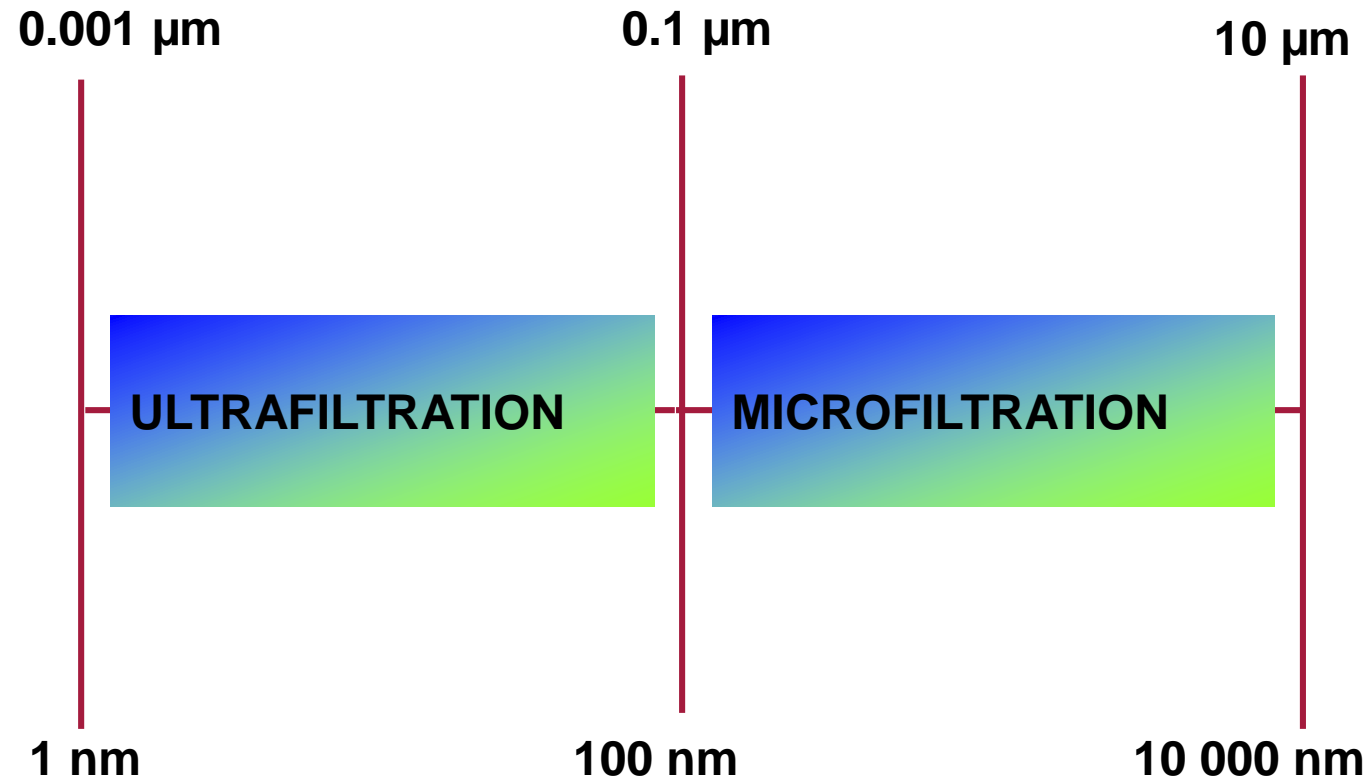


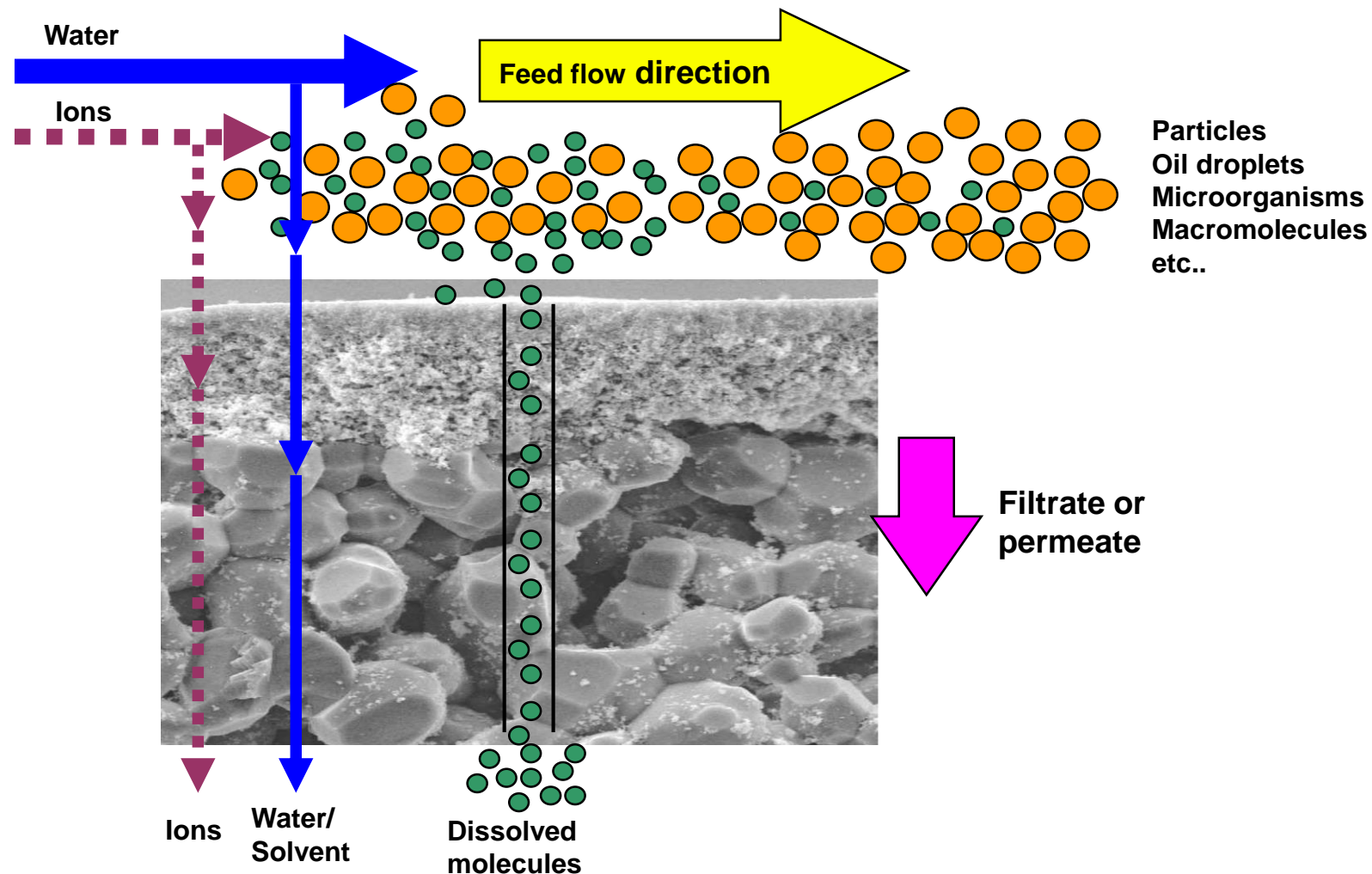
## Membralox® ceramic membranes



## Microza® PVDF membranes

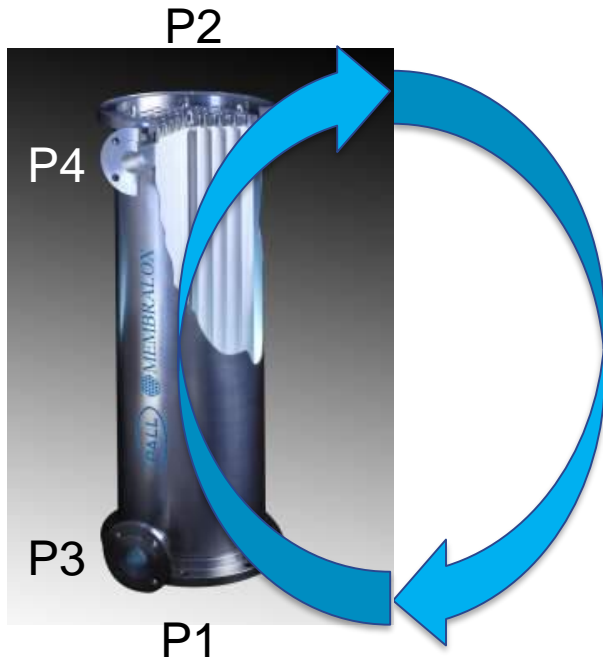








## Filtration Loop



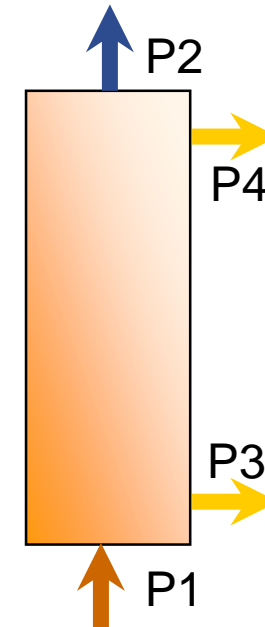
## Trans Membrane Pressure

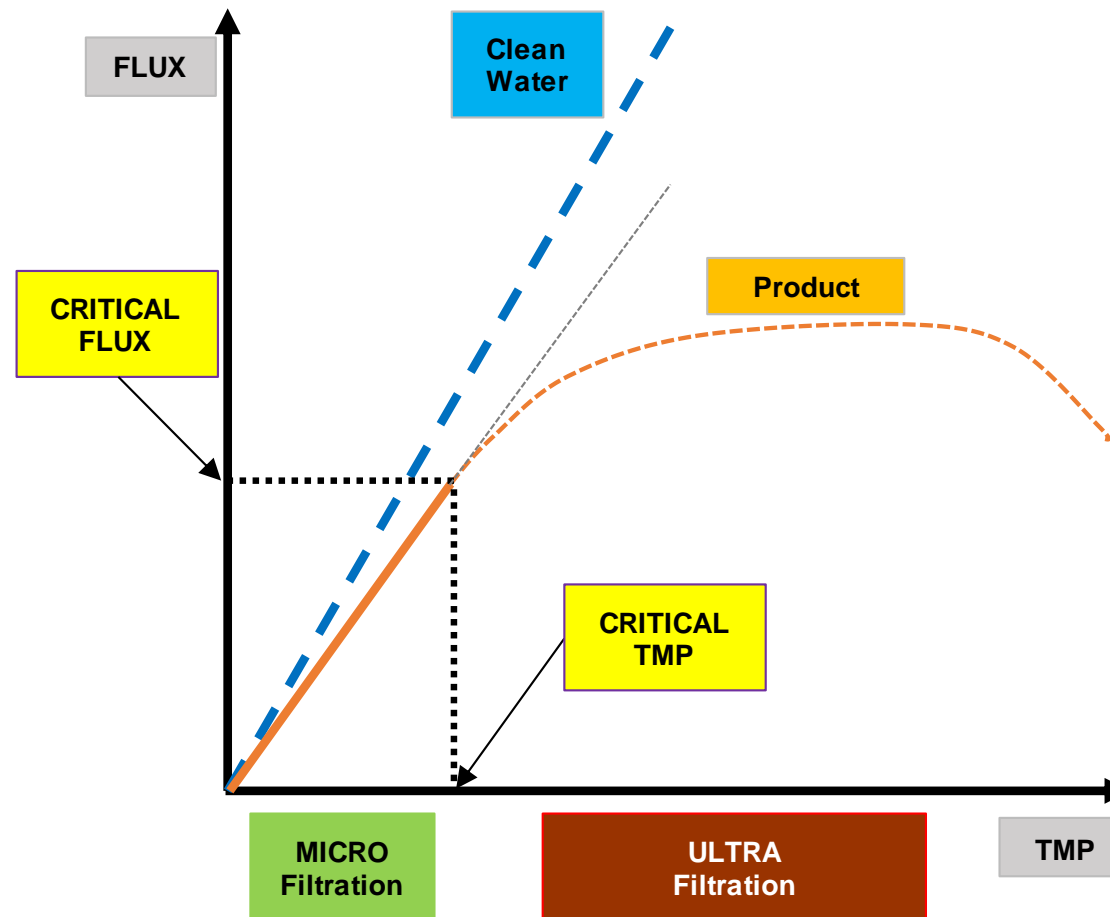
$$TMP = \frac{P1 + P2}{2} - \frac{P3 + P4}{2}$$

TMP : Trans Membrane Pressure  
 P1 : Pressure inlet (bar)  
 P2 : Pressure retentate outlet (bar)  
 P3 : Top pressure filtrate outlet (bar)  
 P4 : Bottom pressure filtrate outlet (bar)

### TYPICAL VALUES :

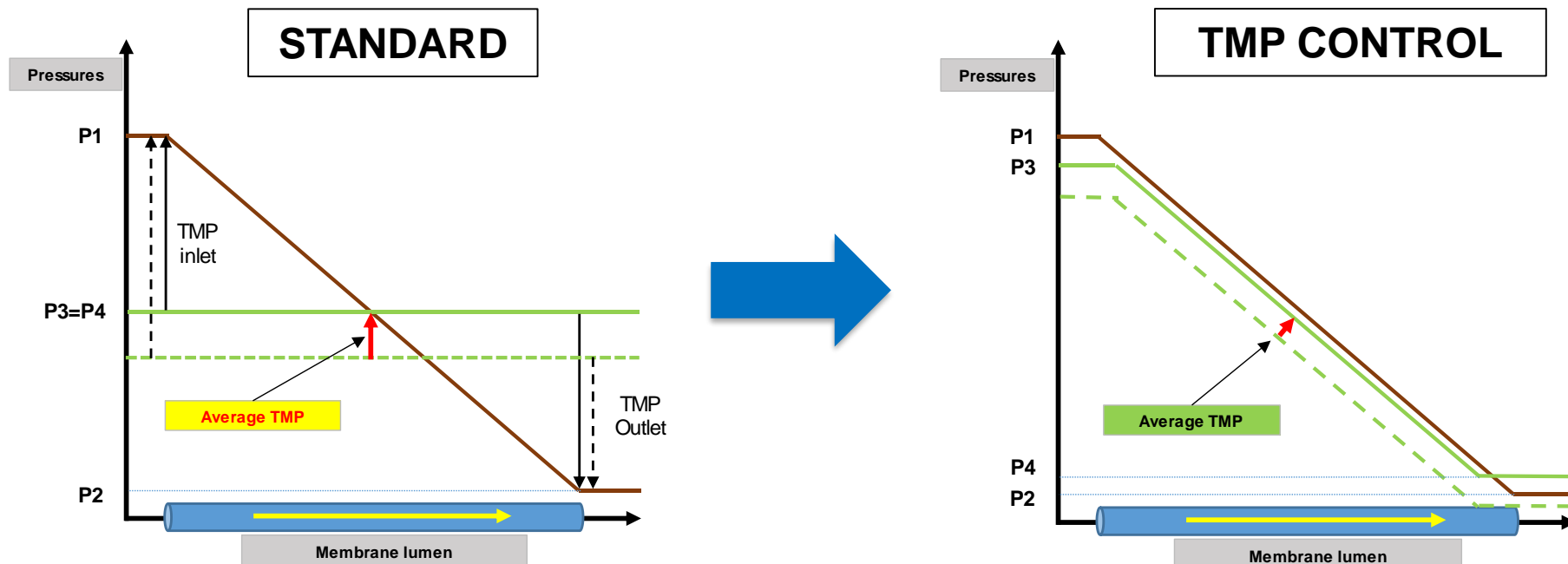
Microfiltration : 0.1 to 2 bar  
 Ultrafiltration : 2 to 10 bar





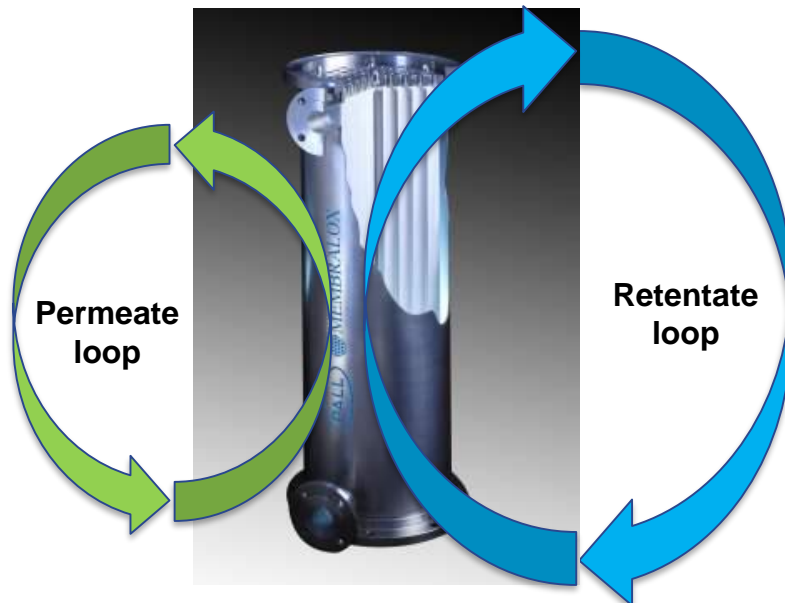
## Performances optimization:

- **Capacity** (permeate flux) → **High Delta P** (high shear at membrane surface) and
- **Yield** (protein transmission) → **Low TMP** (all over membrane length)



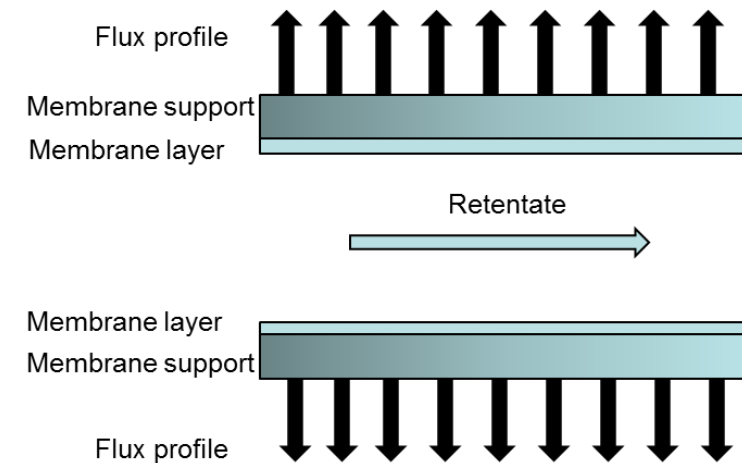
## TWO SOLUTIONS

Hydraulic solution:  
**UTP (Uniform Transmembrane Pressure)**



Membrane solution:  
**GP (Graded Permeability)**

**Modified Support Structure  
With Unchanged Filtration Layer**



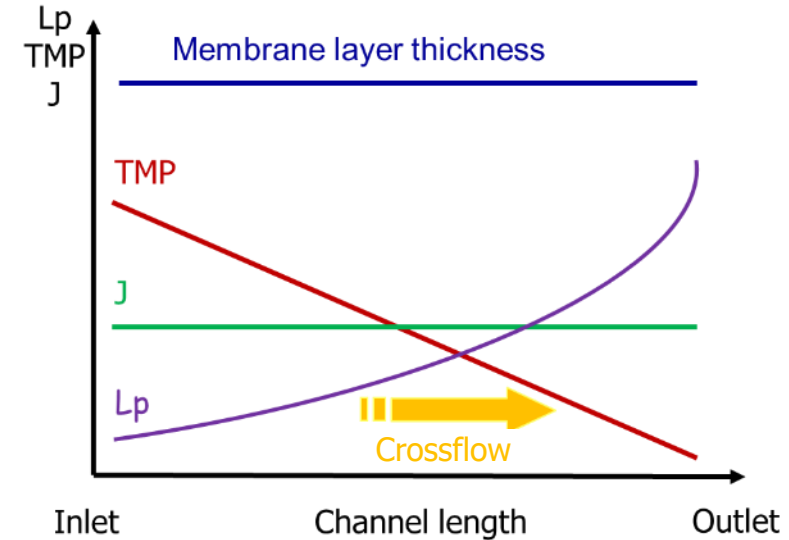
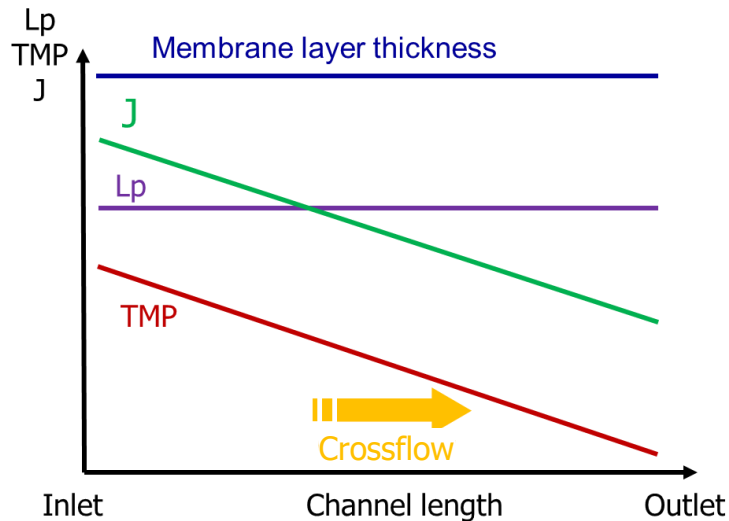
$$J(x) = \text{TMP}(x) * L_p(x)$$

**Standard** membrane :

$$L_p(x) = K \text{ constant}$$

**GP** membrane :

$$L_p(x) = \text{Permeability Gradient}$$

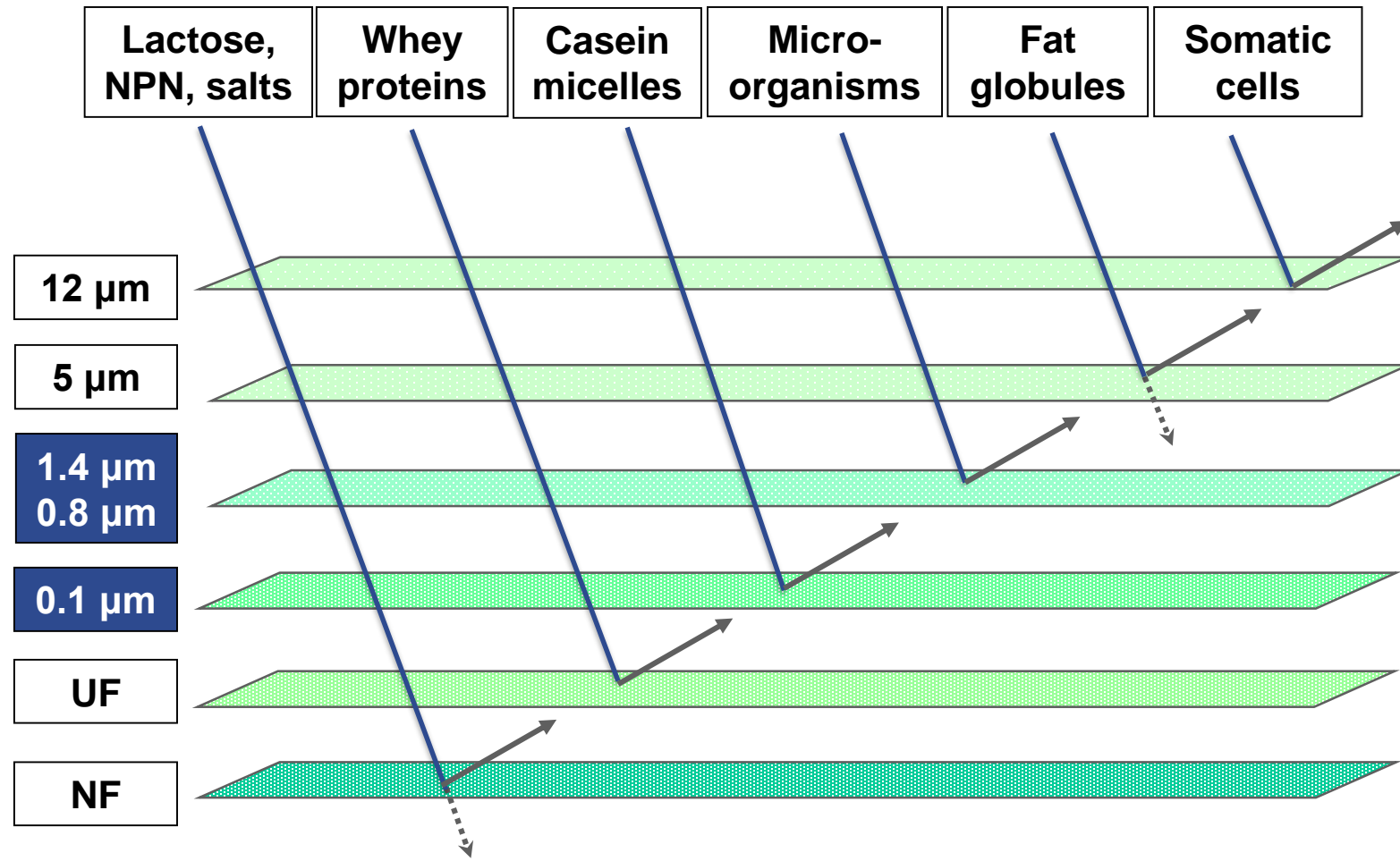


**J** : Resulting permeate flux

**$L_p$**  : Water permeability

**TMP** : Transmembrane pressure





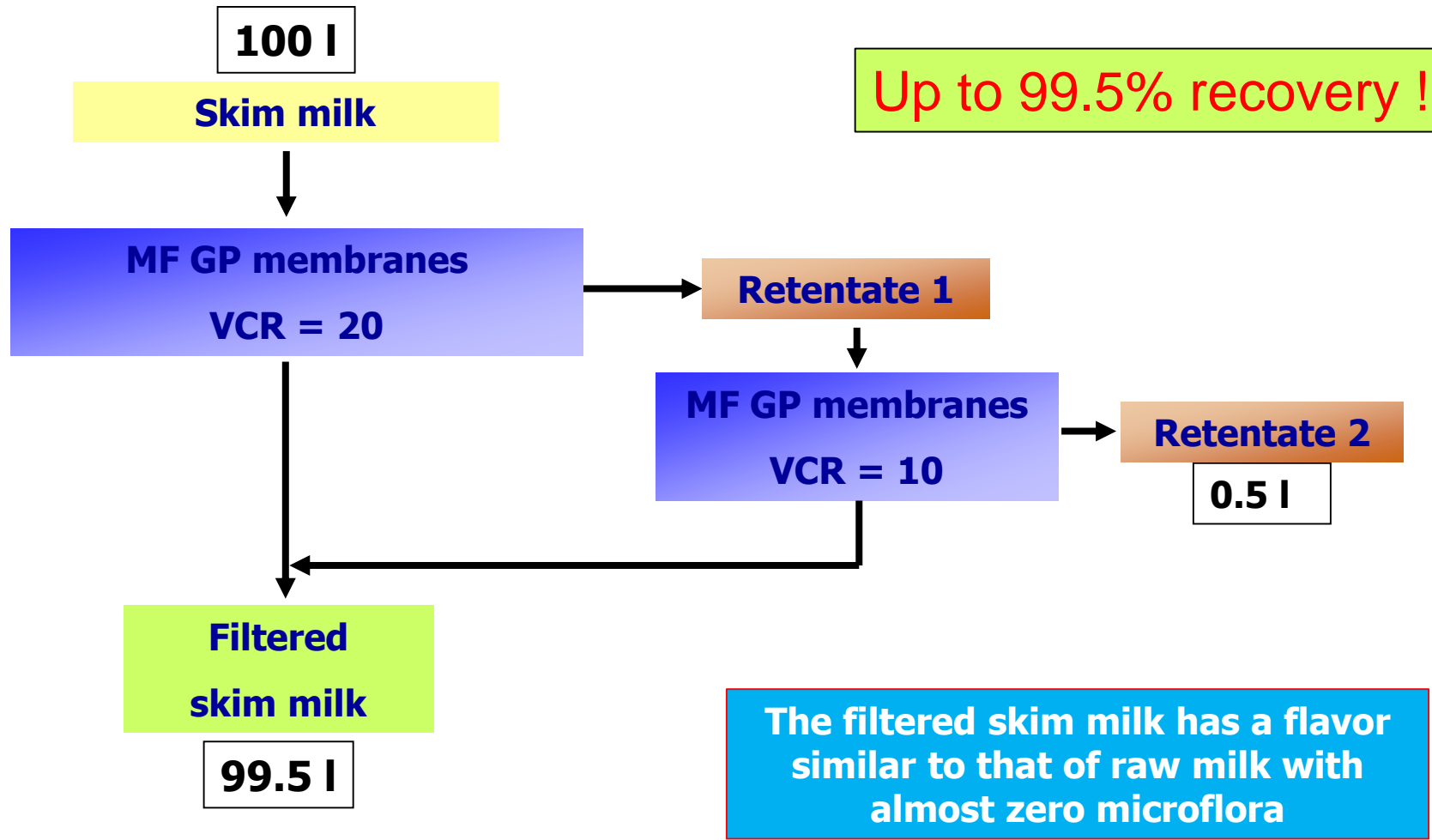
- **Bacteria removal** from:
  - ✓ skim milk,
  - ✓ whey,
  - ✓ protein concentrates
- **Milk fractionation** to produce
  - ✓ native micellar casein concentrates
  - ✓ « ideal » whey
- Cheese **brine clarification** and reuse

### Advantages of Microfiltration

upstream of thermal pasteurization (72 °C/15 sec)

- to significantly reduce microbiological load and somatic cells
  - ✓ at low temperature
  - ✓ with negligible change in protein content
  - ✓ while preserving the native protein features
- to extend pasteurized milk shelf life up to 4-5 weeks
- to enhance cheese processing (spore removal)
- to improve downstream processing bacteriological quality (concentration, fractionation, *etc.*)

# Bacteria Removal Process Example



Process Parameter	Past. 72°C/15 sec	Past. + bactofugation	Past. + double bactofugation	Past. + microfiltration 1,4 µm	Past. + microfiltration 0,8 µm	130°C/1 sec 127°C/2 sec
Total plate count reduction	1-1.5 log <sup>6)</sup>	2 - 3 log	3-4 log	5-6.5 log	>7 log	Destroy all vegetative cells
Thermotolerant count reduction	No reduction	1 - 2 log	2-3 log	4-5 log	6-7 log	Destroy all vegetative cells
Psychrotrophic Spore count reduction	No reduction	1 - 2 log	2-3 log	4-5 log	6-7 log	>7 log
Achievable shelf life (8°C) <sup>5)</sup>	7-10 days	10-12 days	12-15 days	18-21 days	27-30 days	>30 days
Number of 1L packages with at least one process survivor able to grow at 6-8 °C	100%	100%	100%	1% to 100%	1 in 1000 up to 1 in 100	Less than 1 in 1000

Table from TETRA PAK White Paper, February 2016, [Extending the shelf life of low-acid liquid dairy products for added value](#)





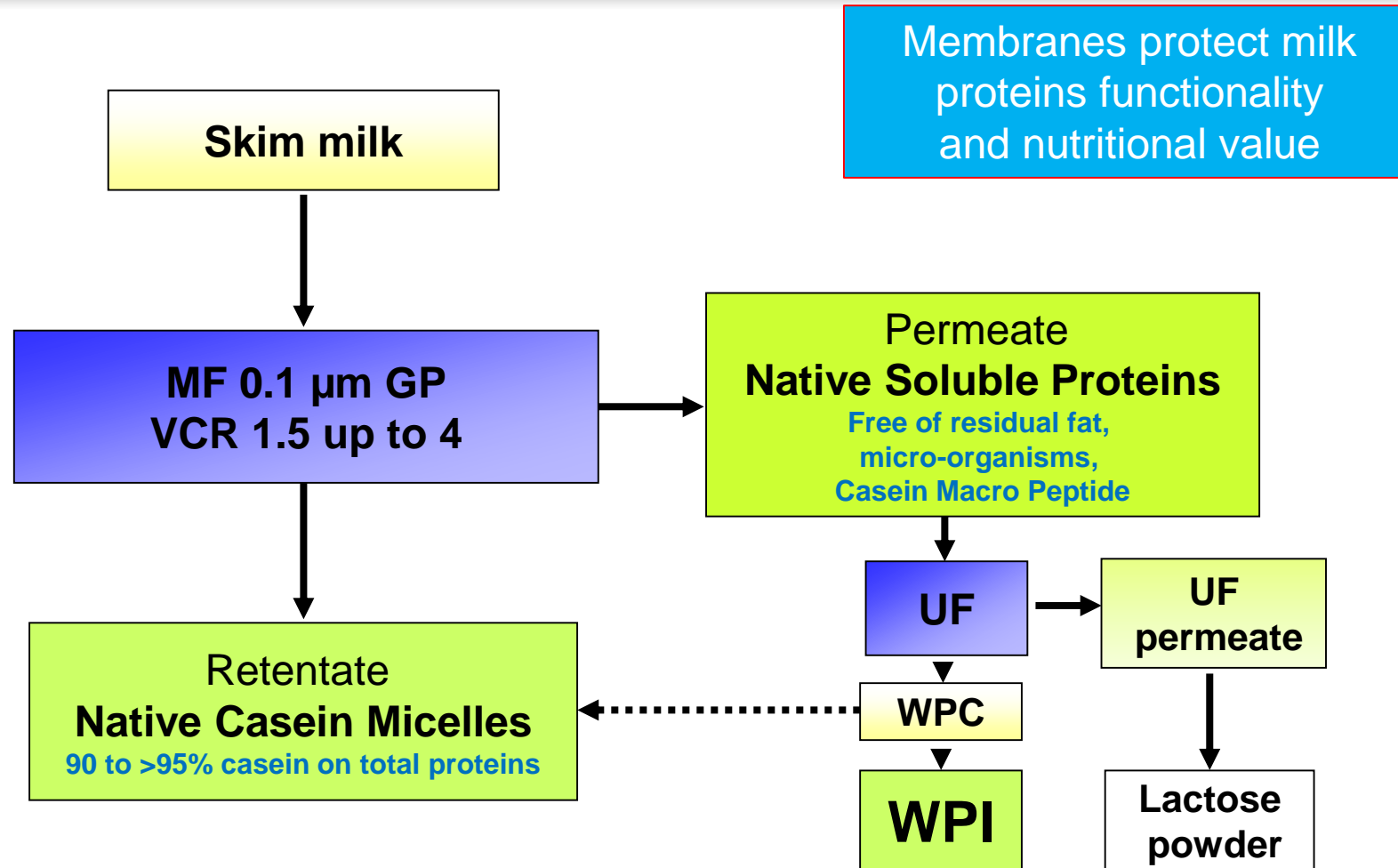
Since the mid 80's, ceramic membranes are used to remove microflora from skim milk.

With the support of **our engineering partners**, this application is continuously growing.

The majority of systems are installed in Europe, however the technology gradually spreads over the globe.

The current installed base of Membralox membranes in this application has a **filtration capacity of > 40 Million liters per day.**

- **Bacteria removal** from:
  - ✓ skim milk,
  - ✓ whey,
  - ✓ protein concentrates
- **Milk fractionation** to produce
  - ✓ native micellar casein concentrates
  - ✓ « ideal » whey
- Cheese **brine clarification** and reuse



## Micellar Casein Concentrate:

- Cheese-making
  - ✓ ↗ Gel firmness
  - ✓ ↗ Cheese yield
  - ✓ ↘ Coagulation time
- New products
  - ✓ Native casein micelles
  - ✓ Casein fractions
  - ✓ Ingredients

## “Ideal” Whey:

- Cheese making
  - ✓ Addition to retentate after thermal denaturation
- Soluble proteins concentrates
  - ✓ Functionality
  - ✓ Nutrition
- « Native » proteins

To succeed in milk fractionation, membranes must demonstrate:

- Sharp pore size distribution → minimize casein loss in permeate
- Precise pore size calibration → compromise between flux and transmission
- Perfect TMP control → soluble protein transmission

Milk fractionation with ceramics started in the mid 90's using the UTP technology.

Now, the bulk of systems built by our engineering partners uses GP membranes demonstrating exceptional performance and reliability.

Quickly adopted in France, this application is gradually spreading throughout the rest of the world since the early 2000's.

The current installed base of Membralox membranes in this application has a capacity to process about 14 Million liters/day of milk to produce:

- 4 Million liters/day **casein concentrate** (90% casein / Total proteins)
- 10 Million liters/day « **ideal** » **whey** (< 0.2 g/l casein; > 4 g/l whey proteins)



- **Bacteria removal** from:
    - ✓ skim milk,
    - ✓ whey,
    - ✓ protein concentrates
  - **Milk fractionation** to produce
    - ✓ native micellar casein concentrates
    - ✓ « ideal » whey
- Cheese **brine clarification** and reuse

## How will your cheese process benefit from using brine clarification system?

- additional protection of your cheese brand
  - with reduced cross-contamination risk
- Opex savings
  - reduced waste stream volumes
  - no DE filtration
  - long filtration cycles and operating life
- reliability
  - high quality brine
- ..... **one step further in your « green program »**

**Reliable barrier** utilizing 0.1  $\mu\text{m}$  membrane filtration, combining:

- high clarity – removing suspended solids
- high reduction of microbial load

For **longer brine life**



Turbidity down to < 0.8 NTU,  
Microbial removal up to 99.999%  
*Listeria* removal up to > 99.9999%  
Positive environmental impact

More constant cheese quality  
Brand protection  
Opex savings

## Pall Microflow XL Brine

**High Strength  
PVDF  
Hollow Fiber  
membranes**

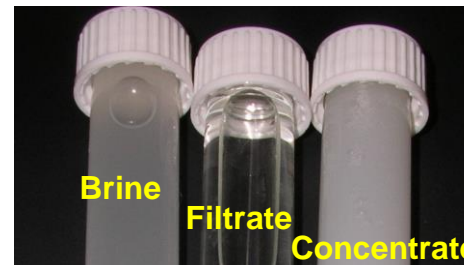


**Reliable brine recovery  
for sustainable value**

## Continuous filtration in kidney loop on the brine pool

- **24h/24h process fully automated**
  - 20 - 21h filtration
  - 3 - 4 hours daily cleaning – intermediate hot water rinse / cleaning cycle
- **Kidney loop for optimized sizing:**
  - 1 % up to 10 % of the total brine is continuously treated per day
- Concentrate is typically 0.3% -1% of filtered brine – down to 0.1% with LCV (Low Concentration Volume feature designed to reduce dead volume at the end of the filtration cycle)
- No salt concentration

**Or batch filtration to a filtrate tank**



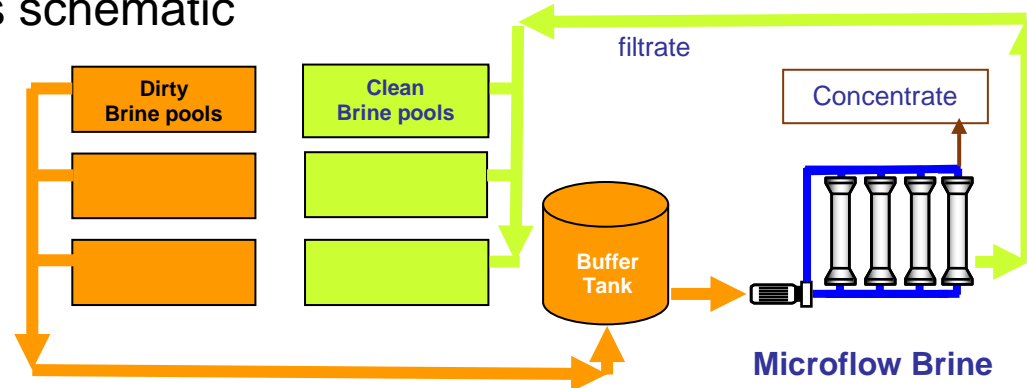
## Benefits for customer:

- Reduction of Listeria contamination risk
- Reduction of operator's health hazards linked to DE powder handling
- Reduction of WWTP pollution load (dramatic reduction of brine discharge)

## Microflow Brine XL-6A performances:


- Average filtration capacity @ 10-12 °C: 4500 l/h
- Turbidity reduction: down to < 0.8 NTU
- Bacteria reduction typical value (LRV): 5 Log
- Global brine losses: < 2%

## Process schematic





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