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MMS AG Membrane Systems

Milk Fractionation

George Bou-Habib

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MMS - Company background

- Founded in June 1995
- Based in Zürich, Switzerland. 30 Employees
- In-house process development, engineering and construction.

- Industrial sectors:
  - Dairy (65%)
  - Food (20%)
  - Bio-Pharma (10%)
  - Industrial Water (5%).

- Product sectors
  - Industrial systems (75%)
  - Laboratory, bench & pilot systems (10%)
  - Process development & consultancy (10%)
  - Maintenance & Service (5%)

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Fractionation

- Fractionation => separating compounds from each other
- Fractionation is predominantly driven by either:
  - Size differences = > Membrane process
  - Charge differences => Electro-dialysis /IEX
  - Absorption differences => Chromatography

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Fractionation processes in the dairy sector

- **Whey protein concentrates**
  (whey proteins selectively retained lactose /ash to pass)

- **Milk protein concentrates**
  (milk proteins selectively retained and lactose/ash to pass)

- **Micellar casein concentrates**
  (Casein selectively retained and native whey proteins to pass)

- **Galcatose-Oligosaccharides concentrates**
  (GOS/Lactose retained and Glucose/Galactose to pass)

- **Whey protein fractionation**

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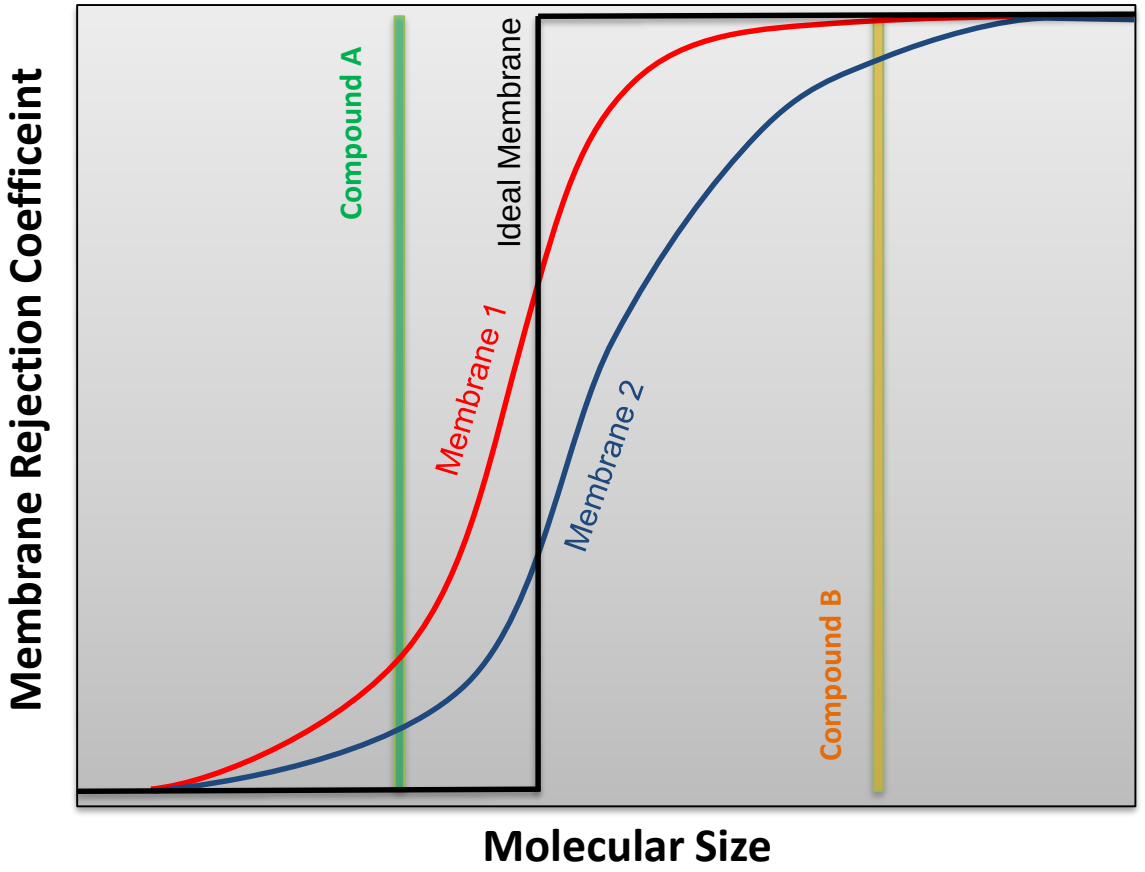
Rejection Coefficient 1



Membranes with different MWCO have different rejection coefficient curves

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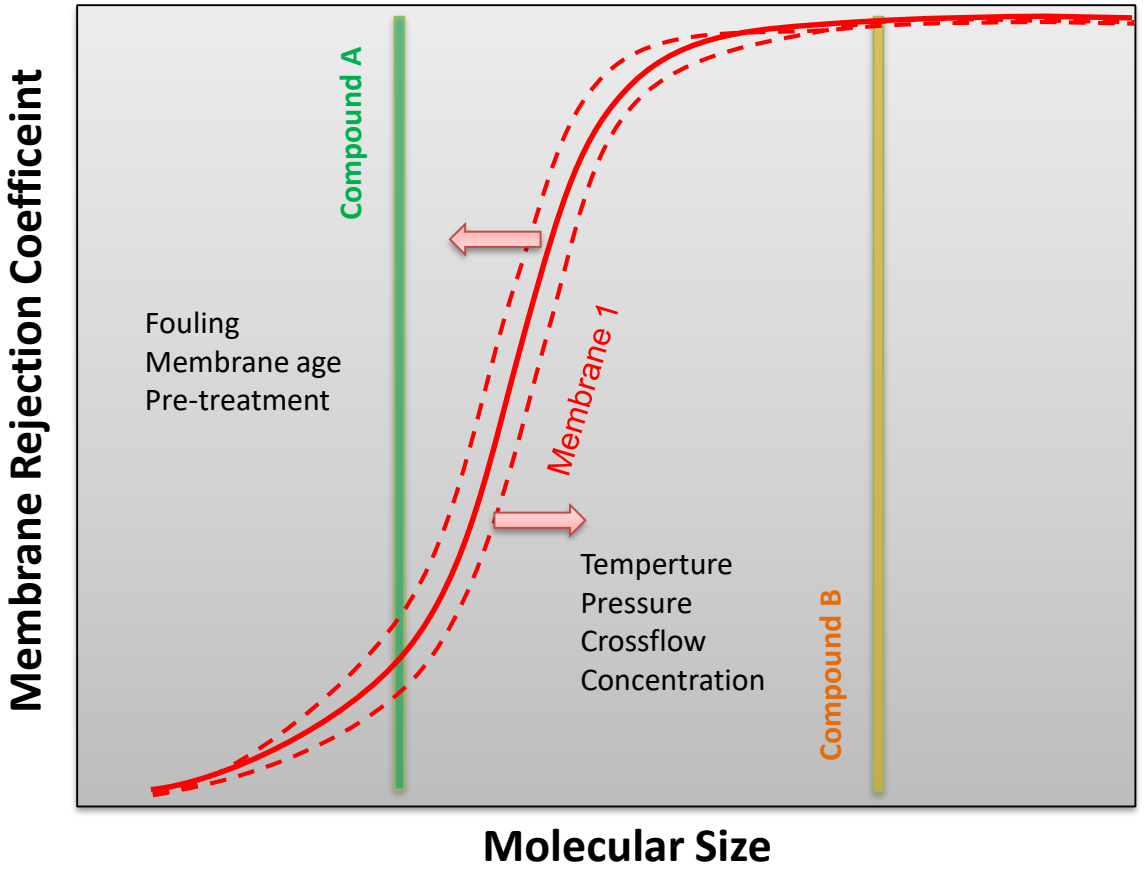
Rejection Coefficient 2



Operating parameters can shift the rejection curve which we can control

Fouling and membrane age can also influence the rejection coefficient which we we need to manage

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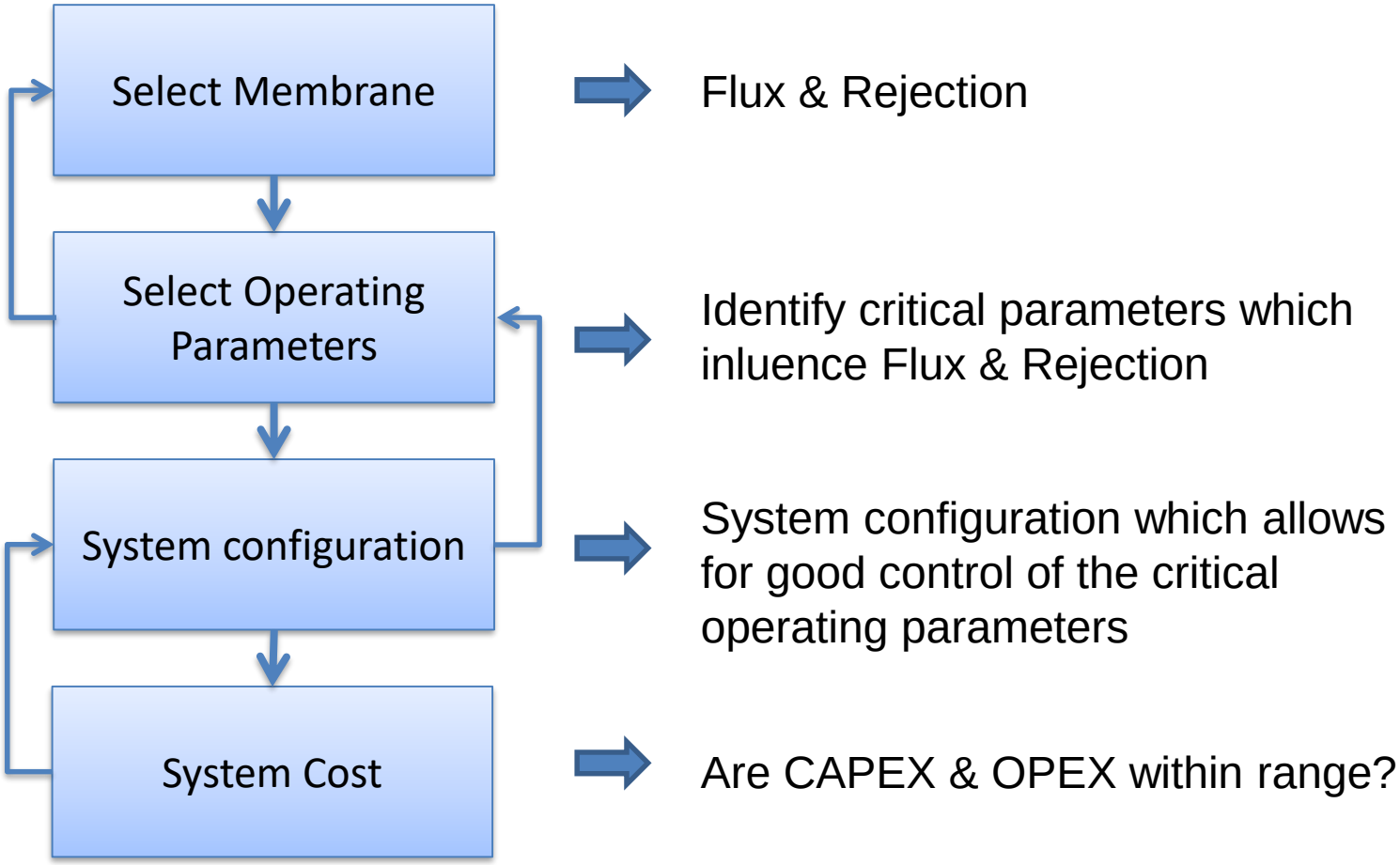
Design Steps – Membrane Process



Although membrane selection is a critical step, the membrane system design should allow the selected membrane to work under the most optimum conditions

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Native Whey

- Skim milk **Fractionation** requirements, e.g. nWPC85 and MCC85
- **Capacity** requirements, e.g. m^3/h or m^3/day
- **System** requirements, e.g. Specific supplier components

Design an industrial membrane system which achieves all of the above with the lowest CAPEX and OPEX

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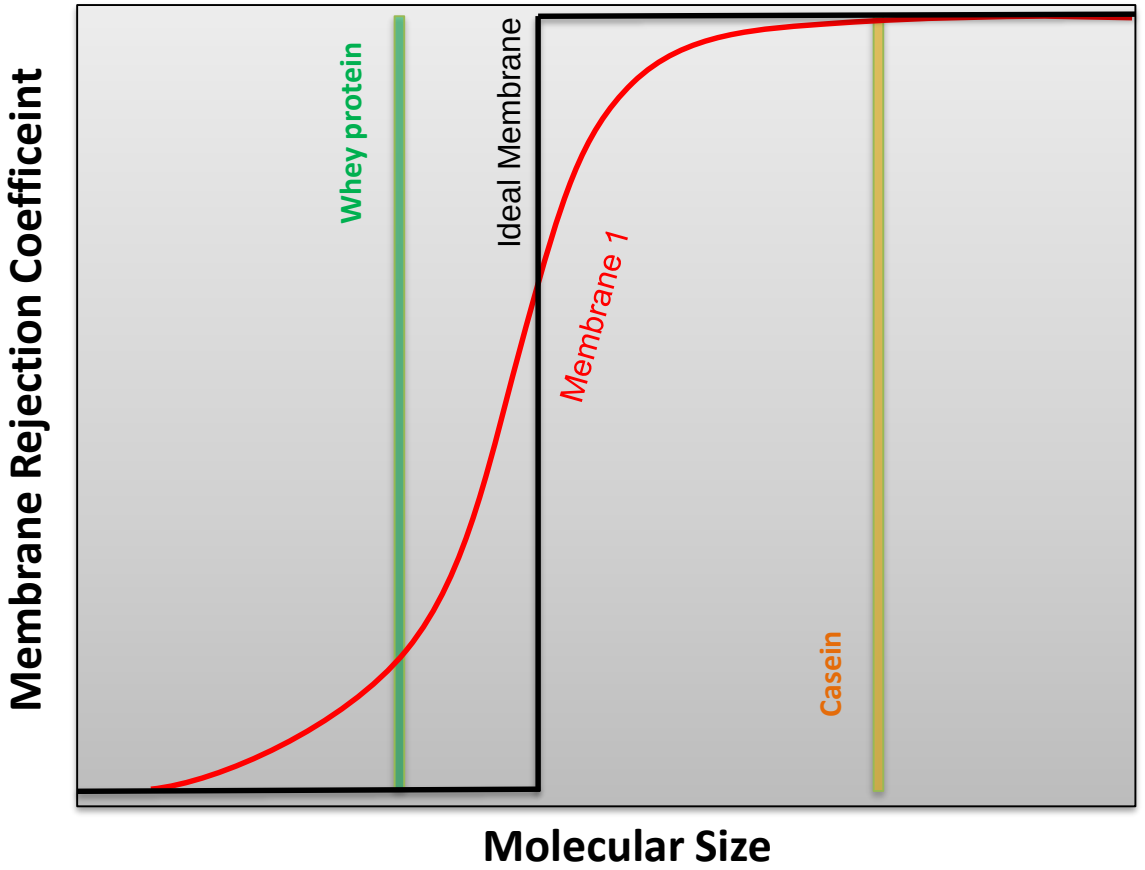
Native Whey – Membrane



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Casein Whey Fractionation

Membrane screening

Nr	Pore Size	Module	Material	Clear Permeate	Est. Rej	TMP	VCR	Temp. (°C)
MF1	0.2 µm	HF	PES/PS	YES	24%	0.5	2	50
MF2	0.45 µm	Ceramic	Ceramic	YES	22%	0.3	2	50
MF3	0.3 µm	SW	PVDF	YES	32%	1.0	2	50
MF4	0.2 µm	SW	PVDF	YES	37%	1.0	2	50
MF5	120 kDa	SW	PVDF	YES	40%	1.0	2	50
MF6	0.3 µm	SW	PVDF	YES	41%	1.0	2	50
MF7	0.05 µm	SW	PS	YES	48%	1.0	2	50
MF9	200 kDa	SW	PA	YES	83%	1.0	2	50
MF11	0.1 µm	SW	PS	No		1.0	2	50
MF12	0.5 µm	SW	PVDF	No		1.0	2	50
MF13	800 kDA	SW	PVDF	No		1.0		50
MF14	0.1 µm	SW	PVDF	No		1.0		50
MF16	0.1 µm	SW	PS	YES	32%	1.0		50
UF1	10 kDa	SW	PS	YES	100%	1.5	5	50

HF – hollow fibre membrane
SW – Spiral wound membrane
Est Rejection and Est. Transmission is based on UV280 data

Membrane selection has a significant impact on fractionation

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Casein Whey Fractionation

TMP & Crossflow Variation

Transmembrane Pressure (TMP) an crossflow changes

Membrane	Pore Size	TMP (bar)	VCR	Temp. (°C)	Frequency Hz	Est. Rej	Flux (LMH)
MF3	0.3 µm	1.0	2	50	7.5	32%	16
MF3	0.3 µm	2.0	2	50	7.5	41%	20
MF3	0.3 µm	1.0	2	50	15	28%	18

- Lower TMP reduces whey protein rejection
- LowerTMP reduces flux
- Higher cross flow reduces whey protein rejection
- Higher cross flow increases flux

Run at low TMPs and high crossflows

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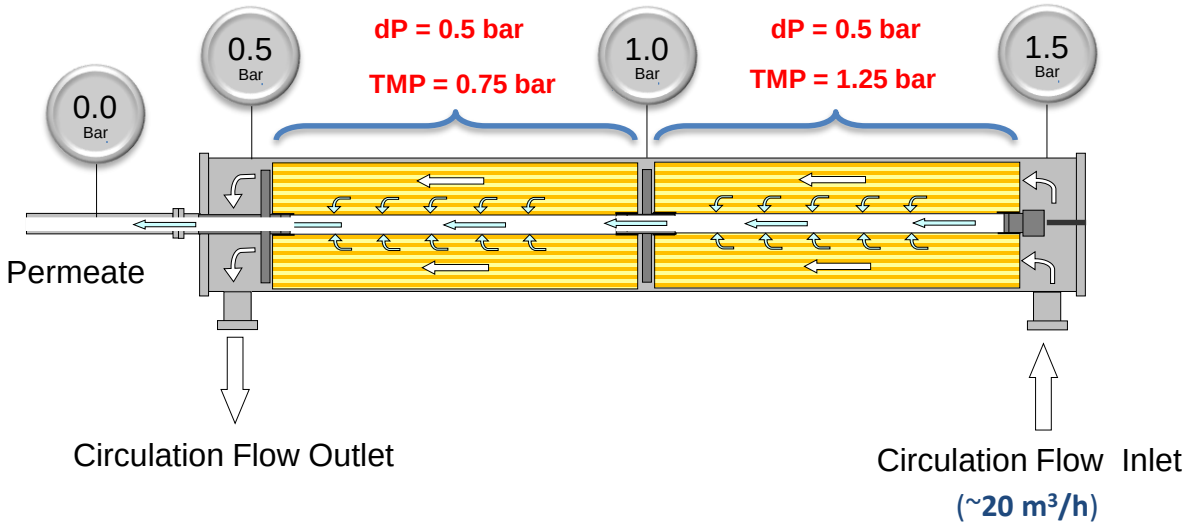
MF Sprial Wound Systems

A standard spiral wound module setup does not allow for high crossflows and low Transmembrane pressures (TMP) due to pressure drop (dP) along the modules.

The higher the crossflow the higher the dP, which results in higher TMP in the first module(s)



Trans-membrane pressure on first module is **0.5 bar *higher***

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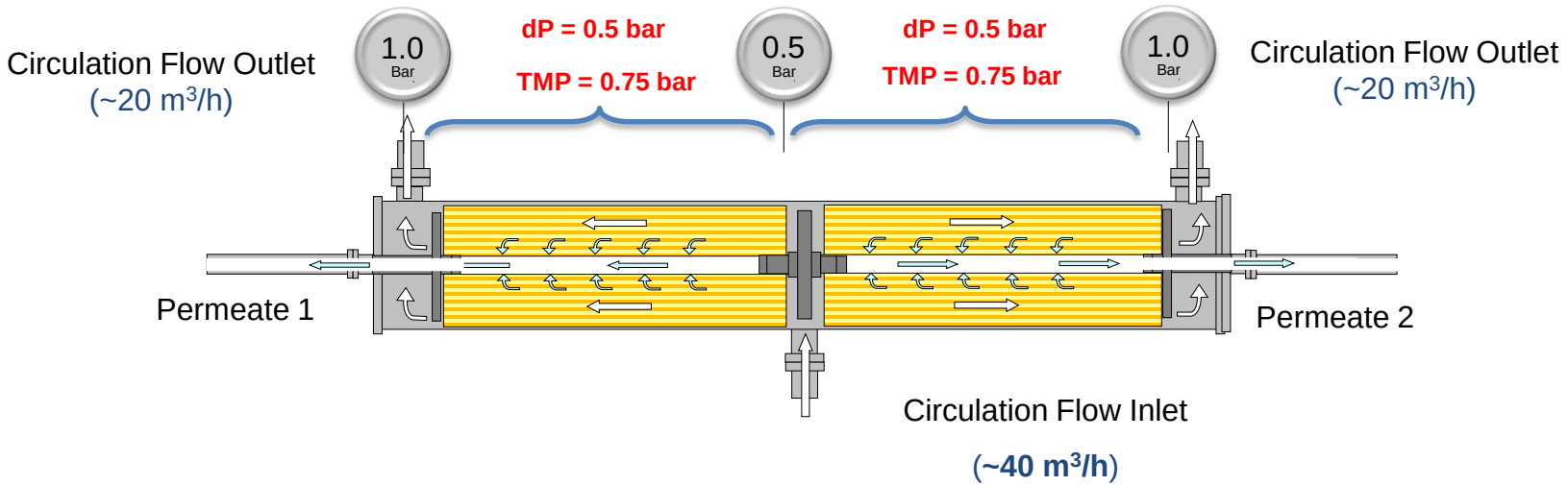
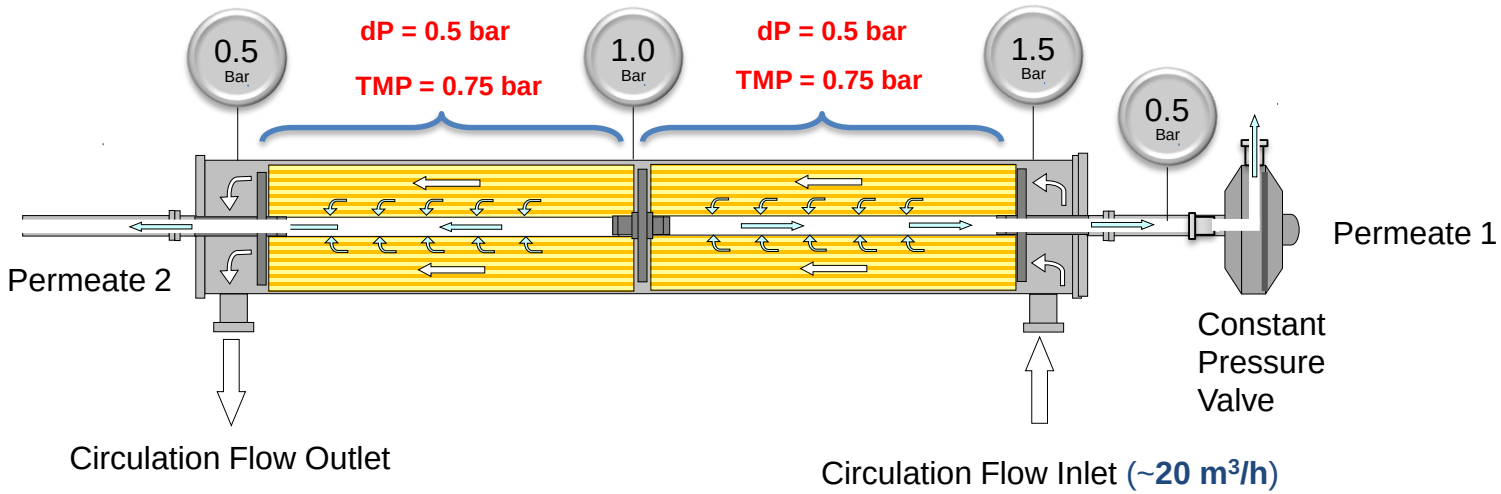
Design feature 1 – TMP optimization





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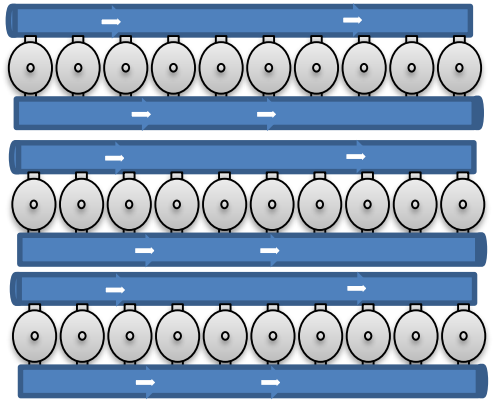
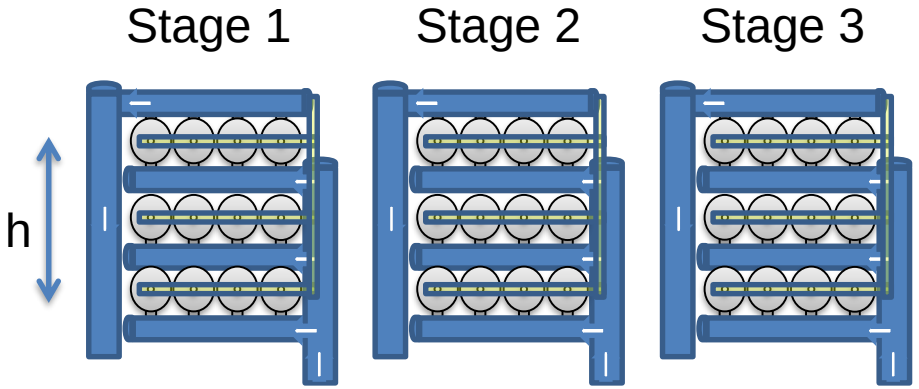
Design feature 2– Hydrostatic pressures

Horizontal layout



dP = 0.1 bar differences from stage to stage

Vertical layout



h = 1000 mm
dP = 0.1 bar differences within one stage

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MMS Industrial Solution

- 5 stage MF unit
- 150 pressure vessels
- Equal TMP concept

System design attempts to manage the critical parameters which influences rejection coefficients and hence fractionation efficiency

- Correct selection of membrane
- Equal TMP concept
- High crossflow with open spacers
- Hydrostatic pressure effects

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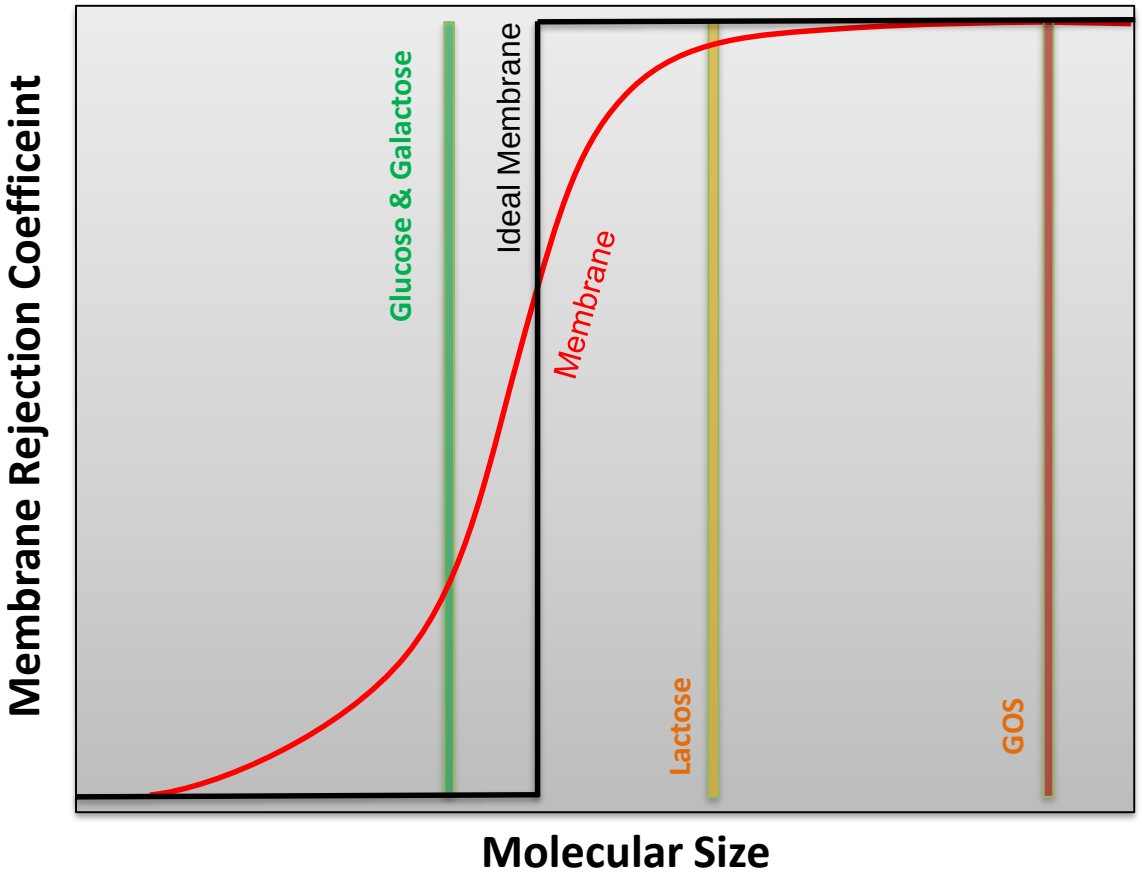
Fractionation of Sugars within the Dairy Industry



Objectives:

Retain all 99% GOS
Retain min 95% of Lactose
Remove 95% of Glu & Gal

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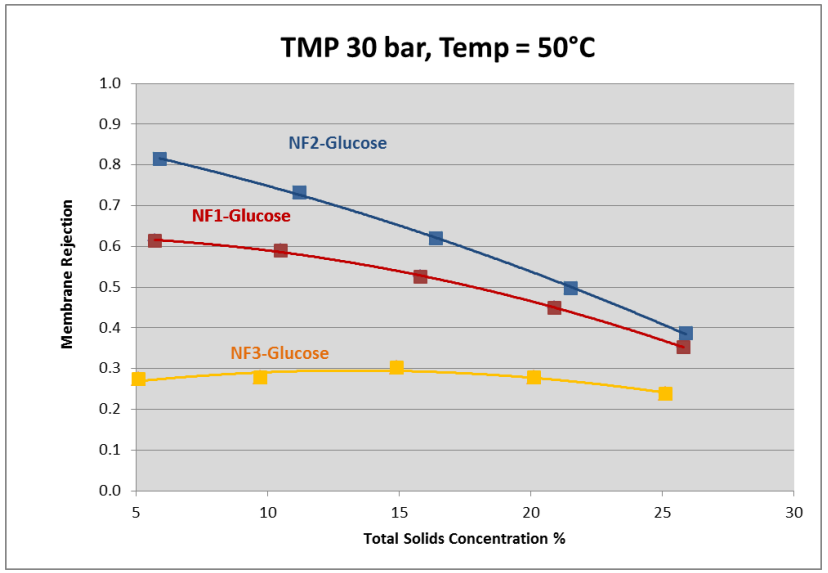
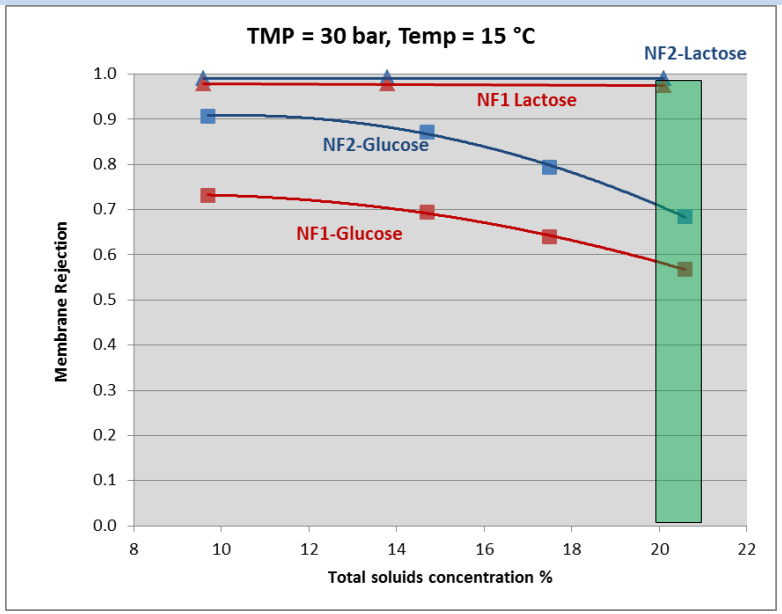
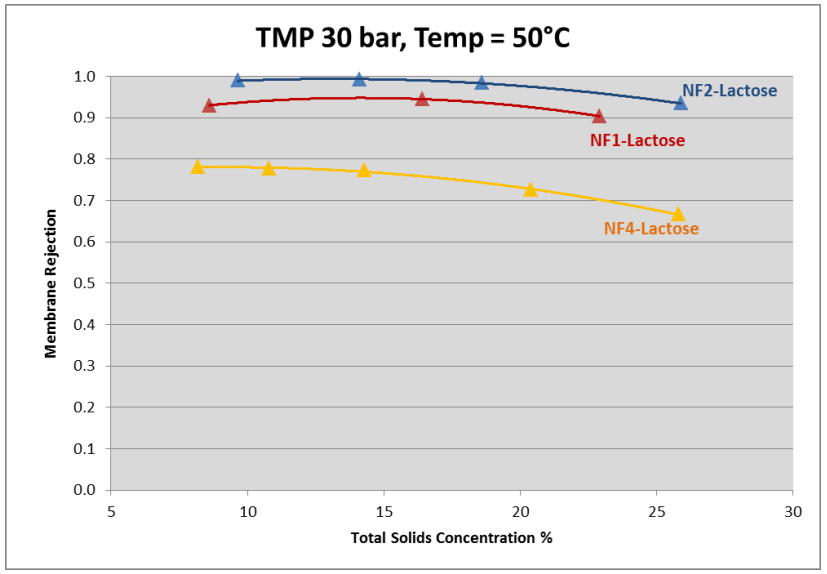
Sugar Fractionation – Oprating parameters







Nanofiltration membranes are significantly influenced by

- Membrane selection
- **High solids concentration**
- Temperature

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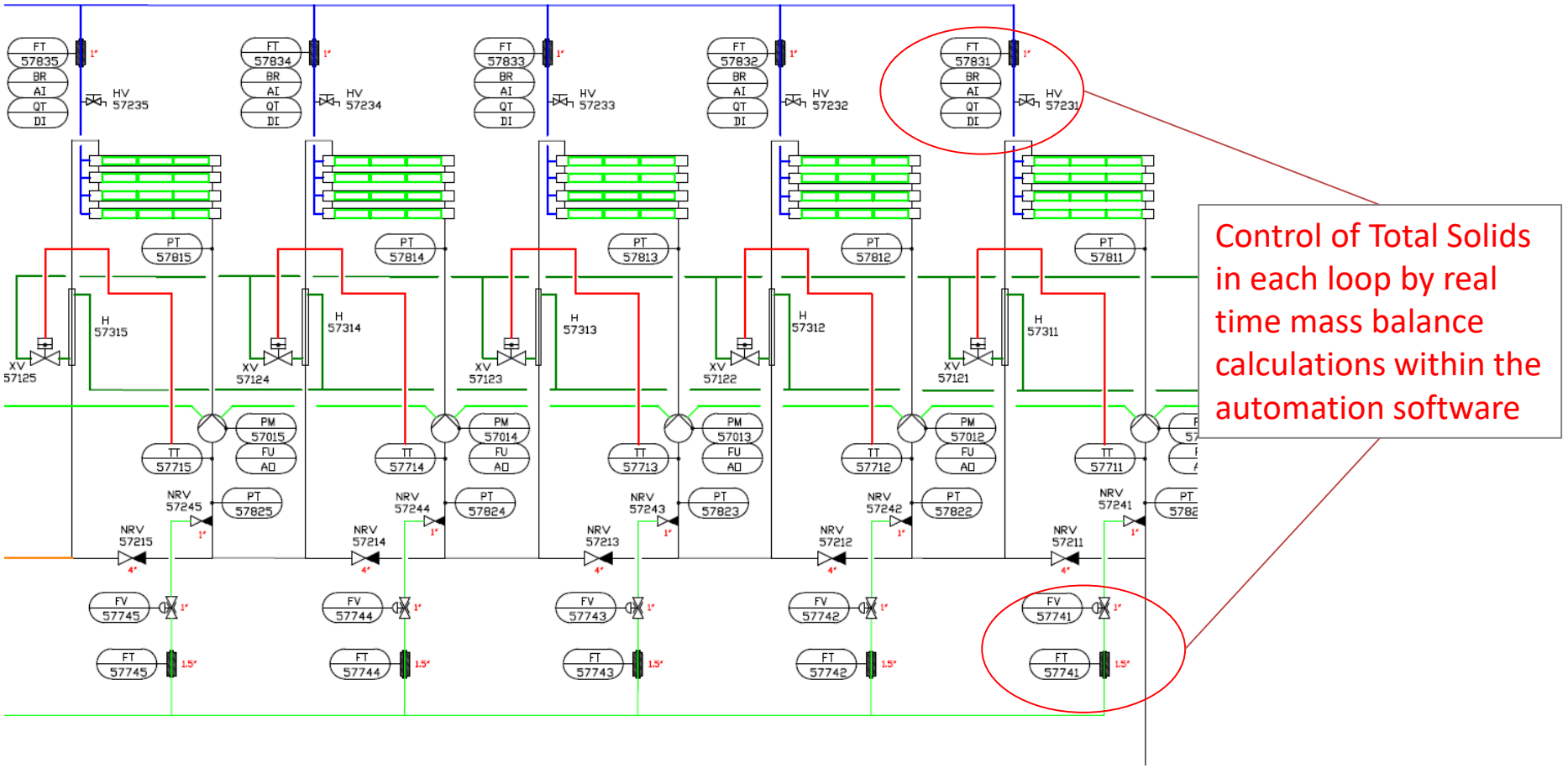
Sugar Fractionation – System Design



Control of Total Solids in each loop by real time mass balance calculations within the automation software

5 Stage NF unit

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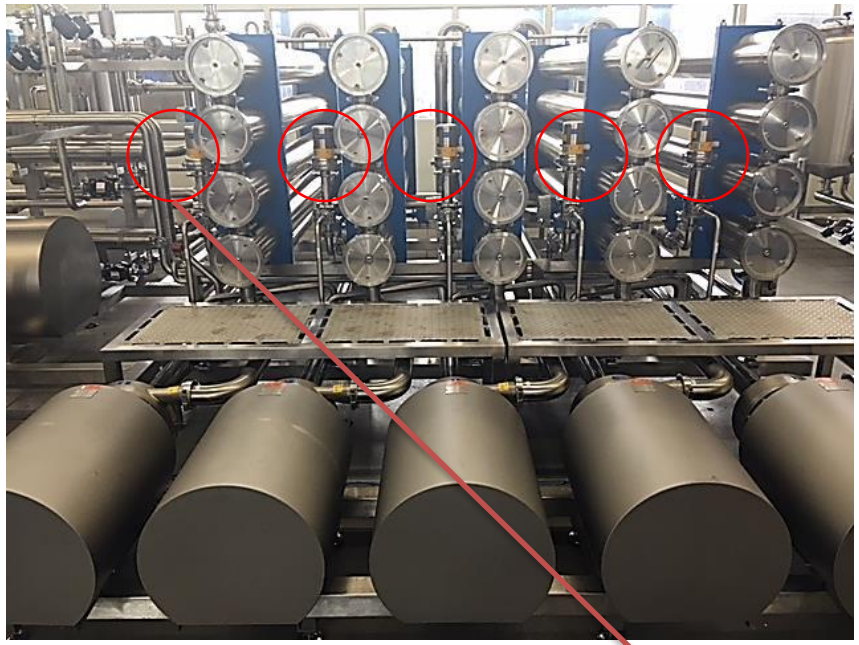
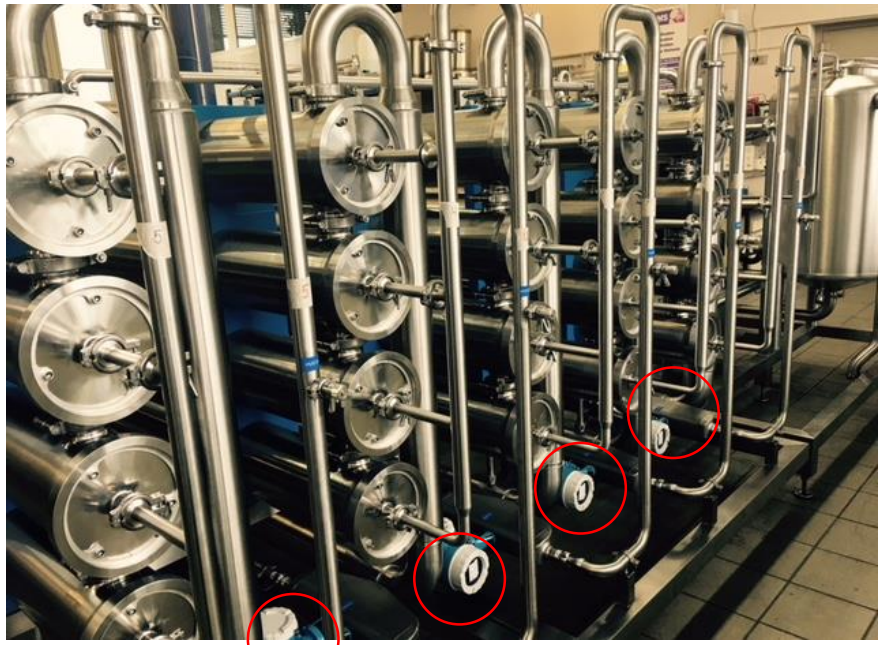
Sugar Fractionation – System Design





A real time mass balance is performed for each loop to accurately control diafiltration flow to maintain the correct concentration and hence rejection coefficient.

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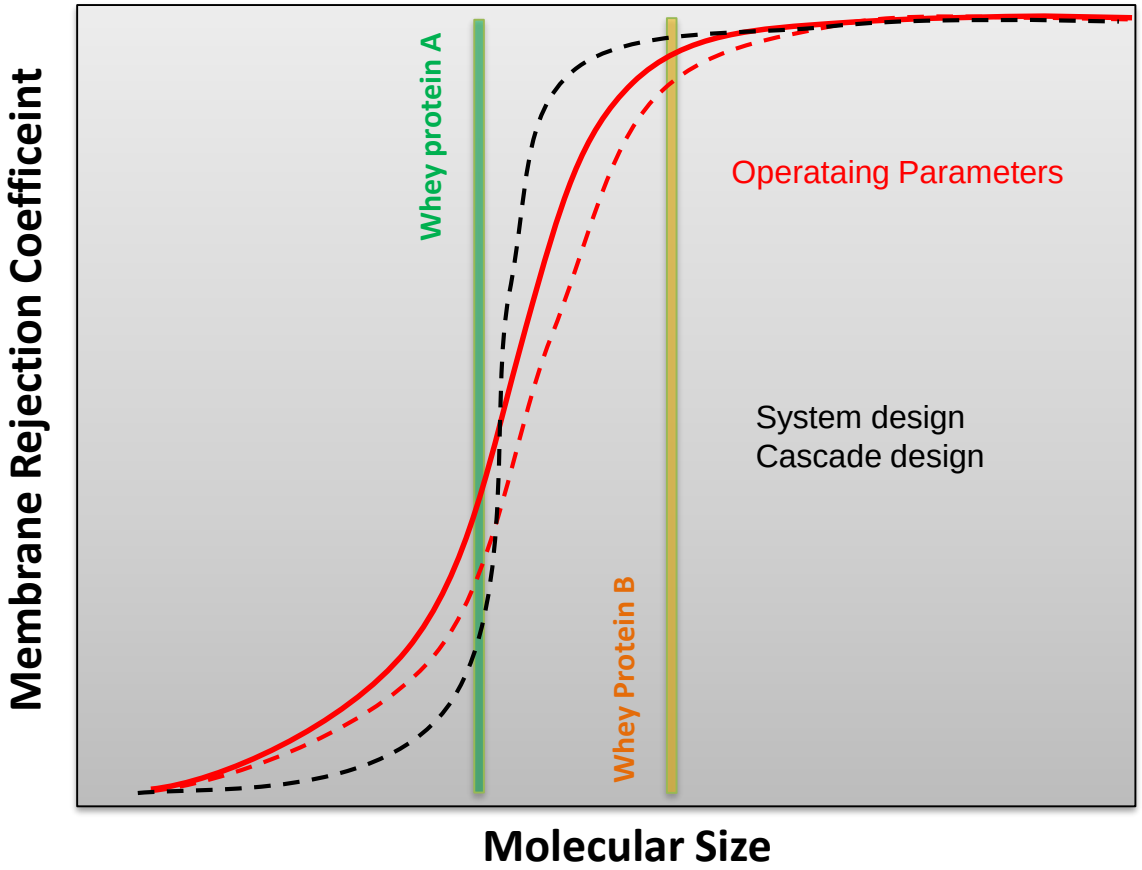
Whey Protein Fractionation



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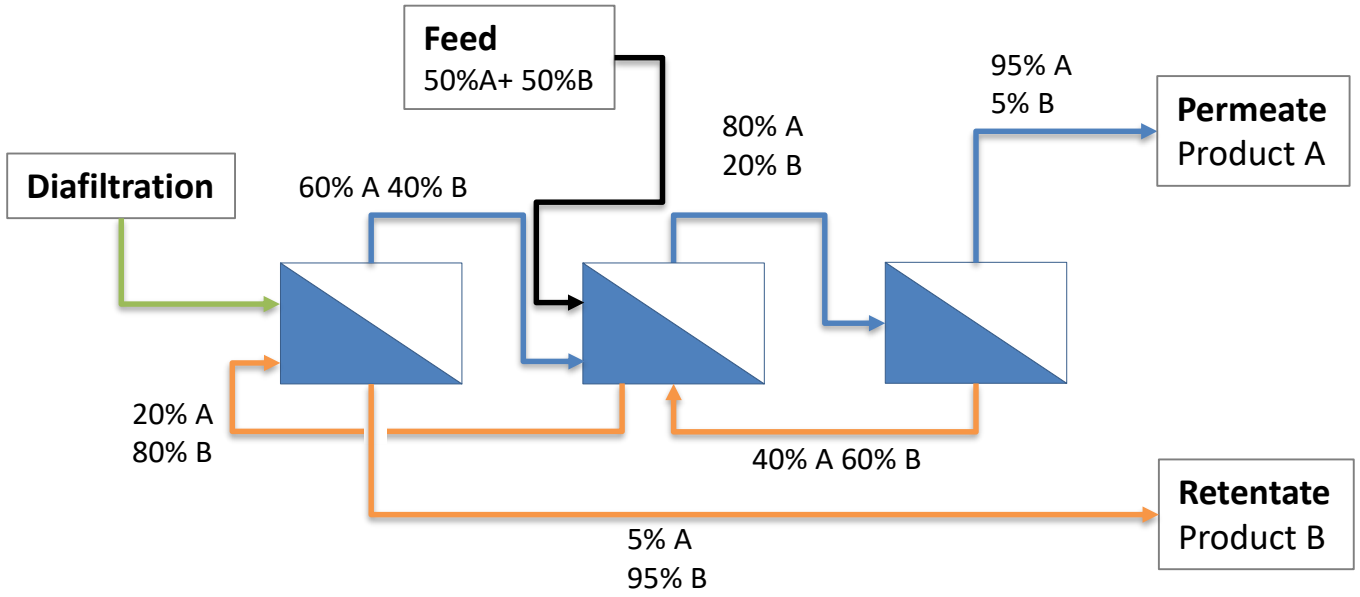
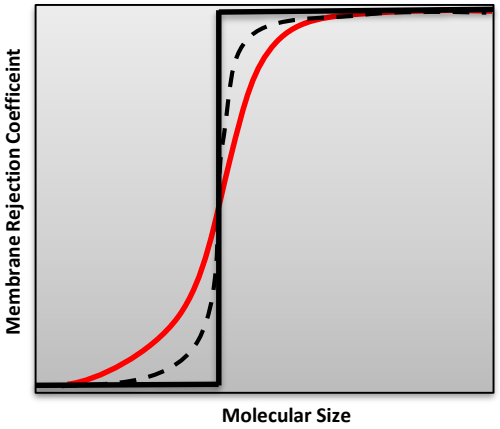
Cascade Membrane Process





Cascade membrane technology allows for higher fractionation accuracy

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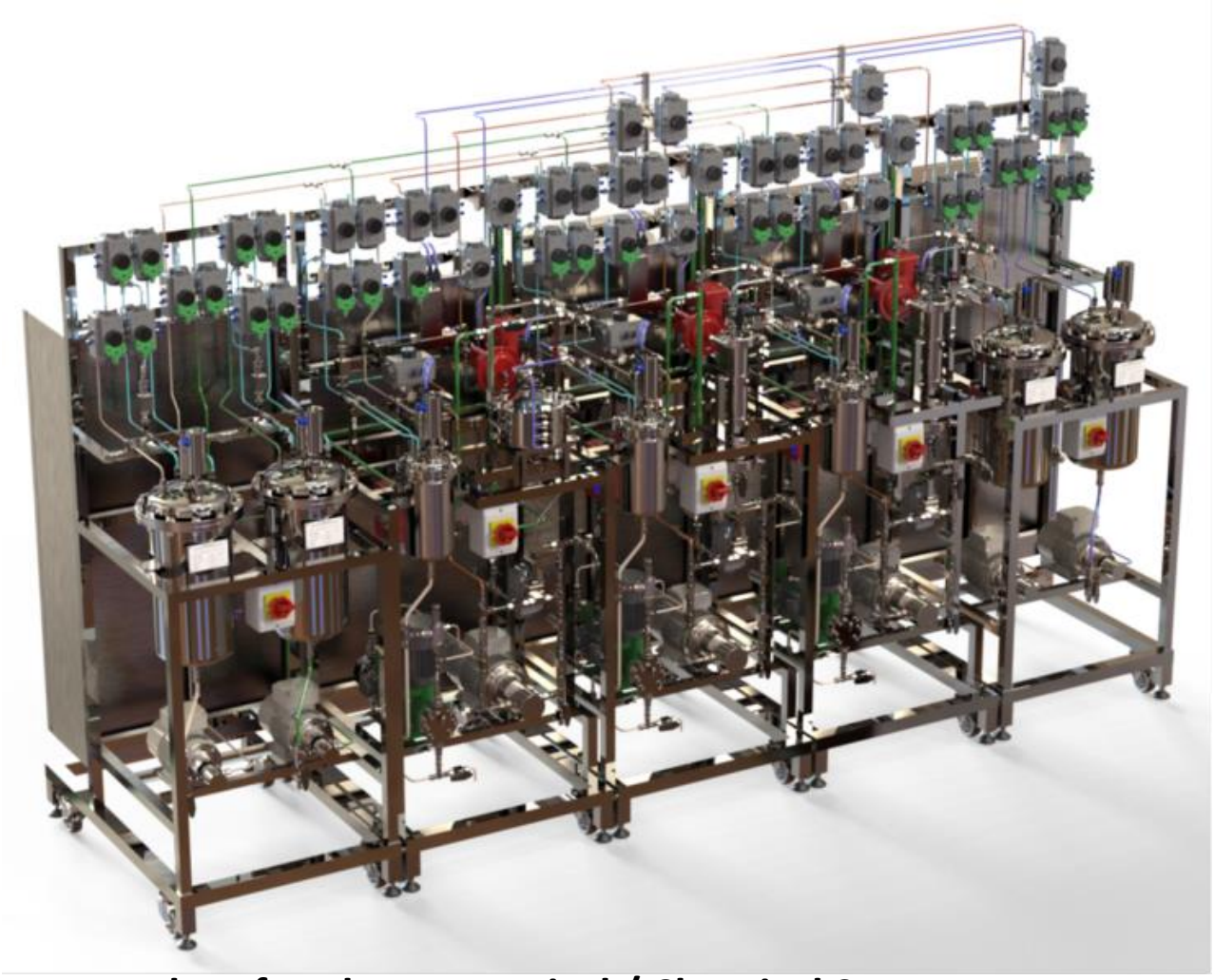
Cascade Membrane Process



Demo Plant for Pharmaceutical / Chemical Sector

Cascade membrane technology is gathering interest in the chemical and pharmaceutical industries to fractionation compounds with similar MW.

Fractionation of whey proteins could be a potential application for the dairy industry.

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Summary

- Membrane systems is a scalable technology for the fractionating dairy products.
- Correct membrane selection is a critical step in designing a membrane fractionation process.
- Operating parameters will influence the performance of the selected membrane.
- The membrane system attempts to incorporate the most suitable membrane, within a design which allows the critical operating parameters to be controlled correctly.
- Membrane based fractionation processes are continually being developed in order to meet the next generation of products which the dairy industry require