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Milk Fractionation with Membrane Technology

Fractionation of milk creates high value products for the dairy sector.

A key technology to achieve this fractionation is **membrane technology** due to its ability to process high volumes of milk in an economic manner.

MMS AG Membrane Systems

Membrane Process Solutions

George Bou-Habib

April 2021

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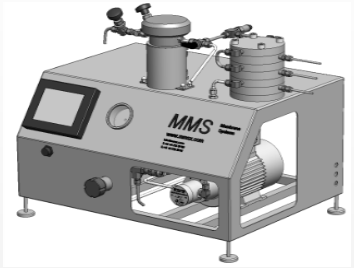
MMS – Membrane Process Solution Provider

- Founded in June 1995
- MMS AG, Switzerland. 30 Employees
- MMS Nordic, Silkeborg, 10 Employees
- In-house process development, engineering and construction.
- Industrial sectors:
    - Dairy (60%)
    - Food (20%)
    - Bio-Pharma (10%)
    - Industrial Water (10%).
- Product sectors
    - Industrial systems (70%)
    - Laboratory, bench & pilot systems (15%)
    - Process development & consultancy (10%)
    - Maintenance & Service (5%)



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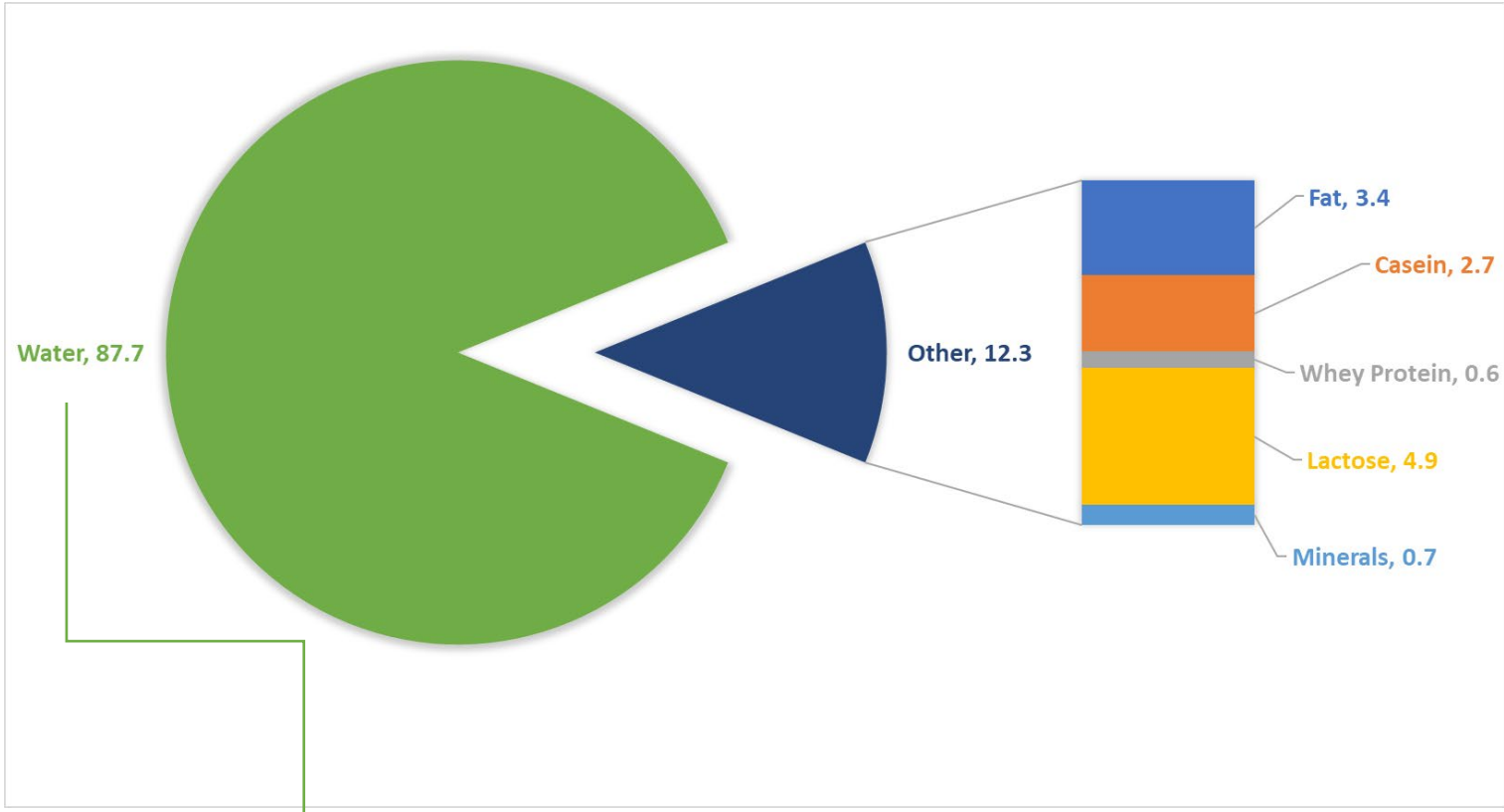
Milk Composition

- Fat 3.4%
- Casein 2.7%
- Whey protein 0.6%
- Lactose 4.9%
- Minerals 0.7%
- Water 87.7%

MCC – Micellar Casein Concentrate



Water - for Diafiltration & CIP

WPC – Whey Protein Concentrate

LAC – Lactose Concentrate

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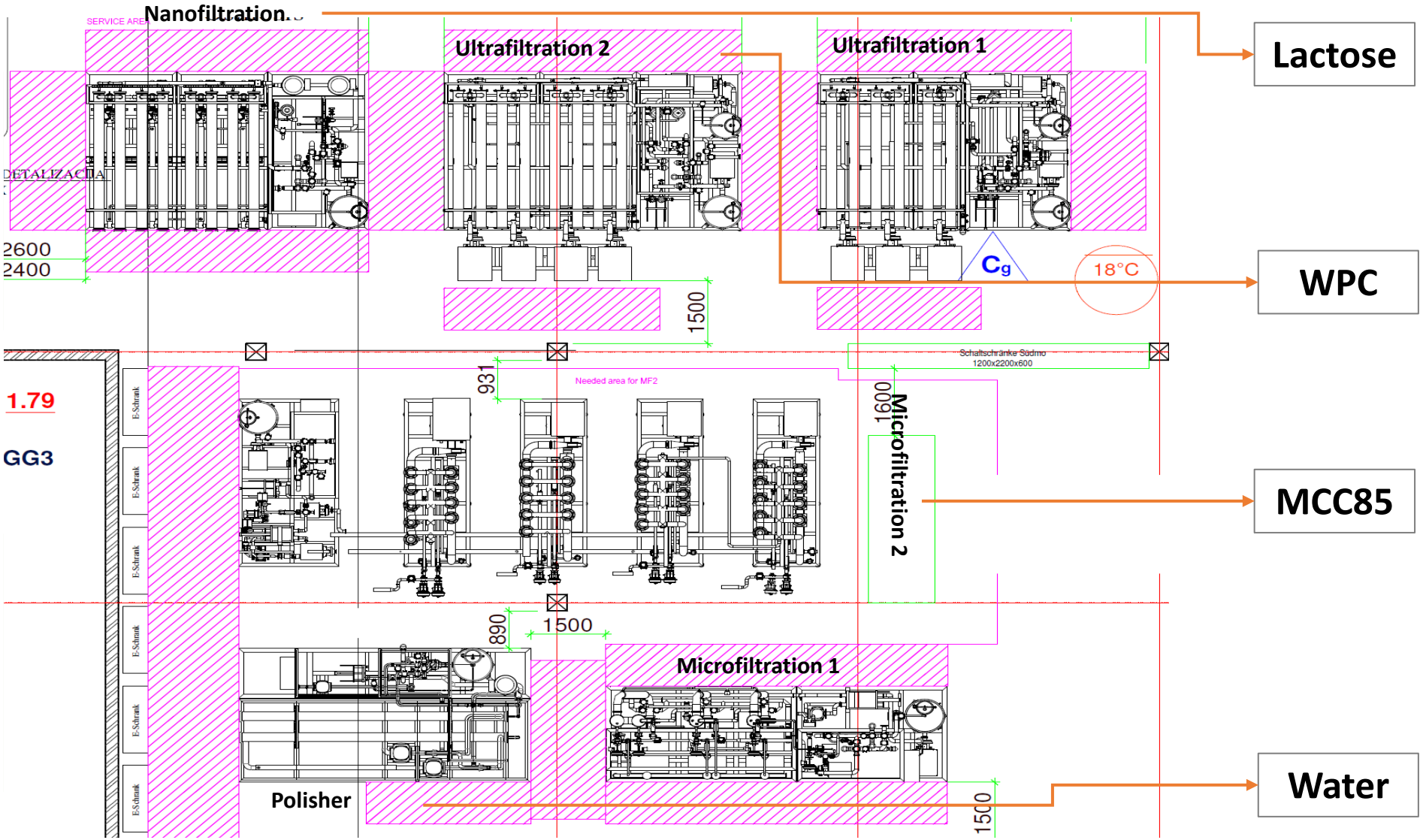
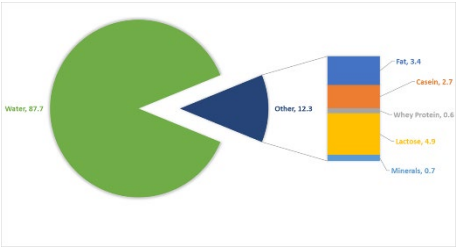
Milk Fractionation Line





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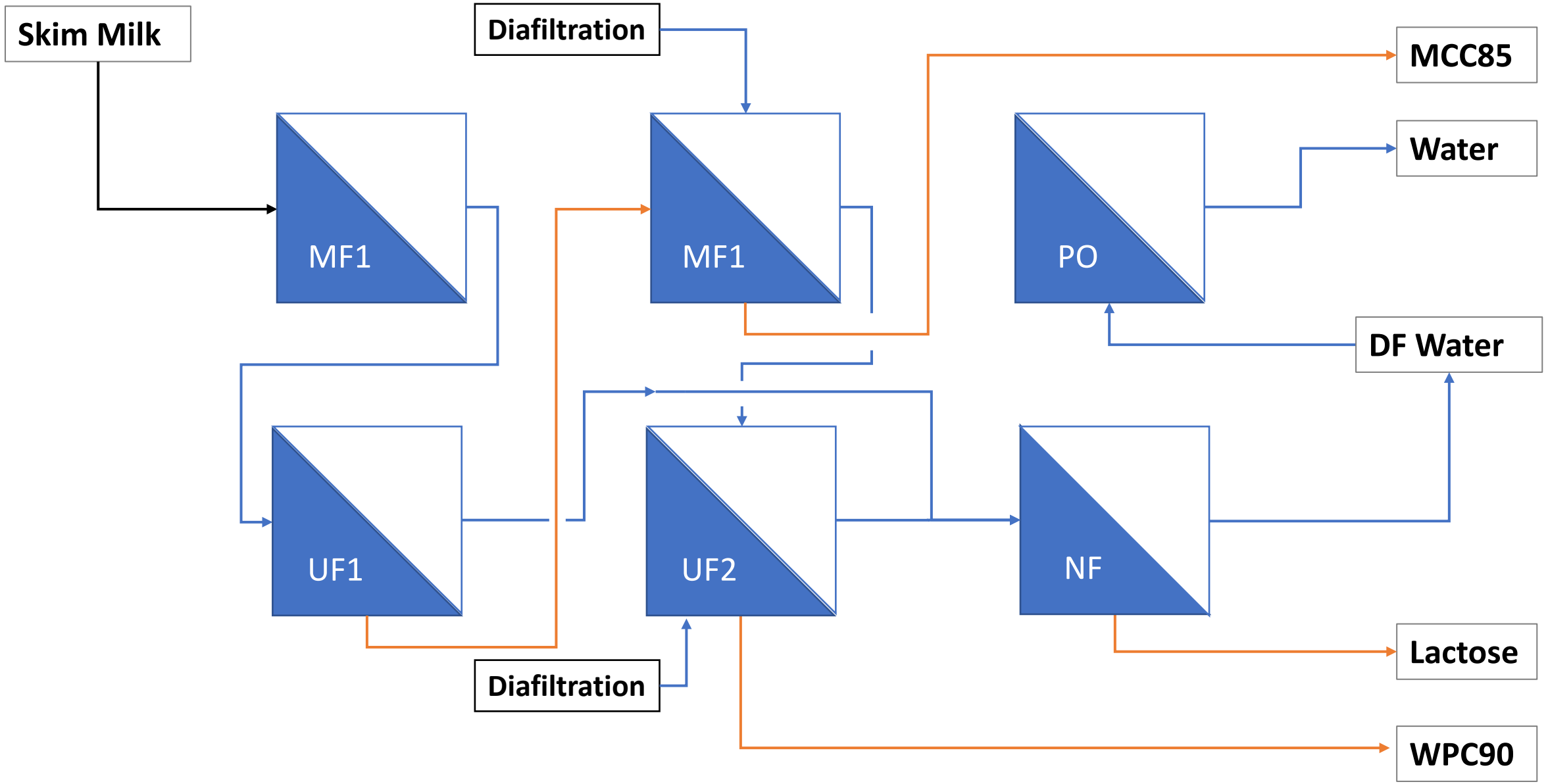
Milk Fractionation Line



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MF1 - Microfiltration 1.4 um

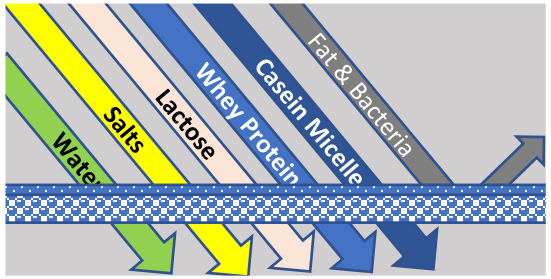
Fractionation of fat and bacterial from skim milk components.

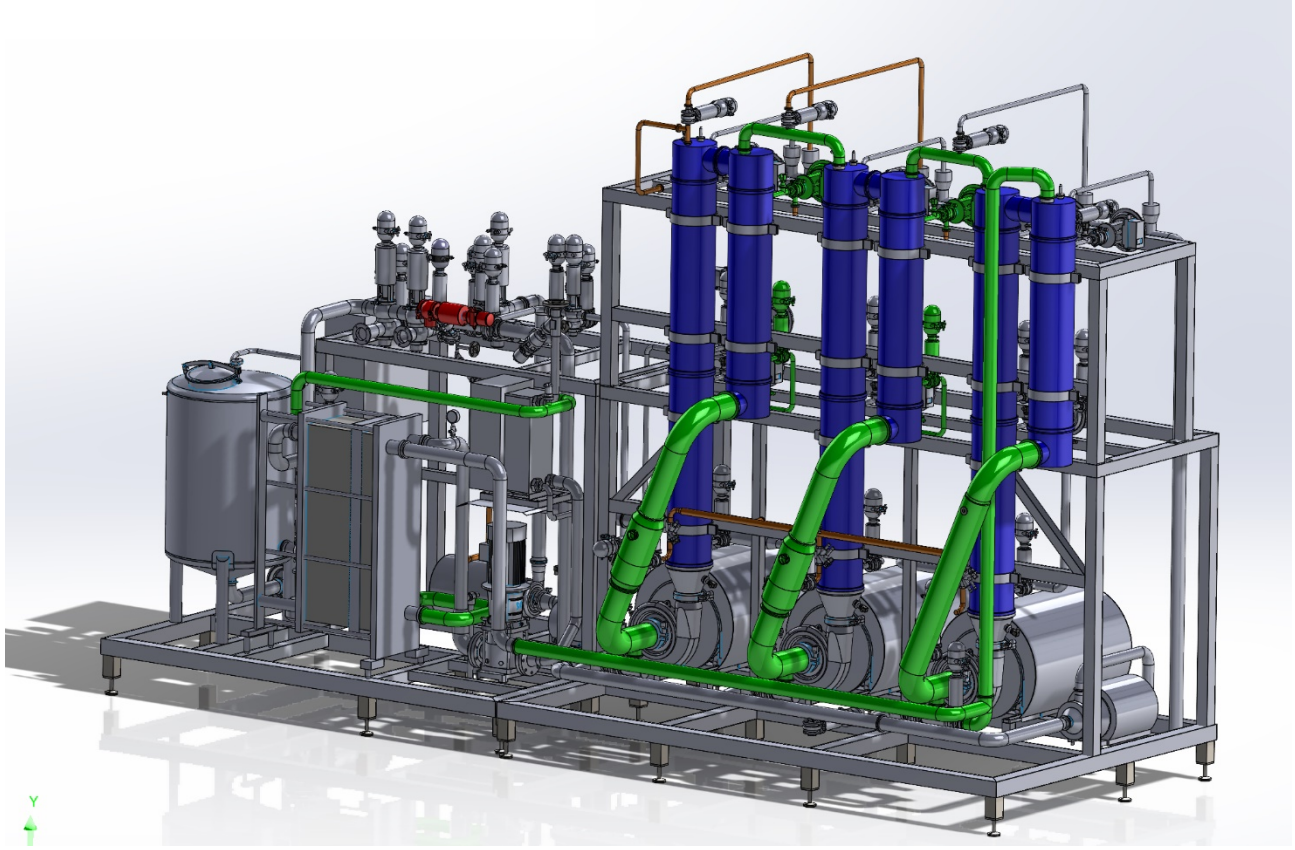
Allows for a more microbially stable process. Log3 removal

Removes fat which allows for higher grades of protein fractions.

40-50 fold concentration of skim milk

MF retentate is fed back to cream pasteurizer





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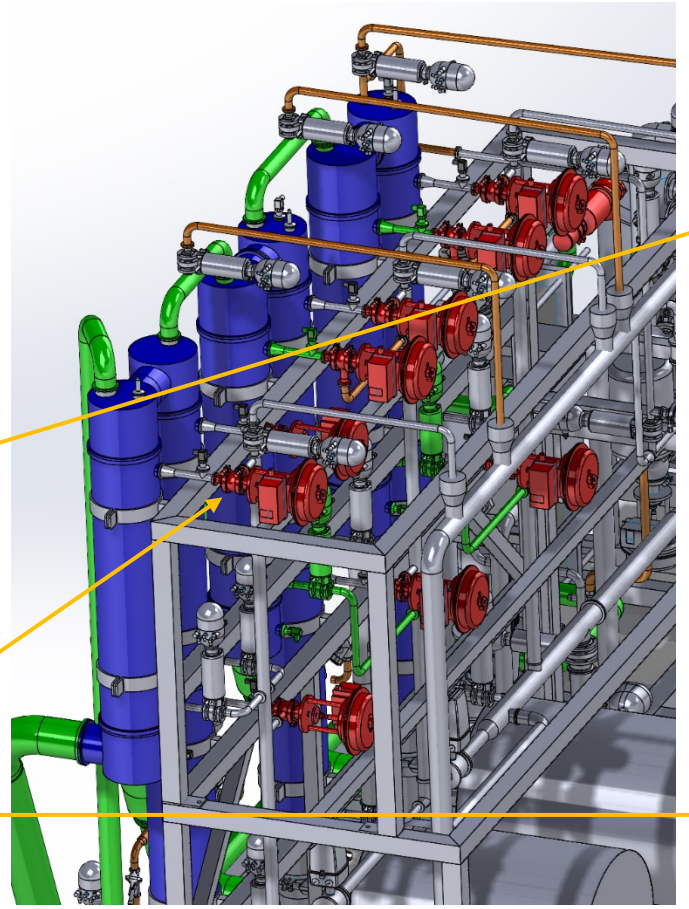
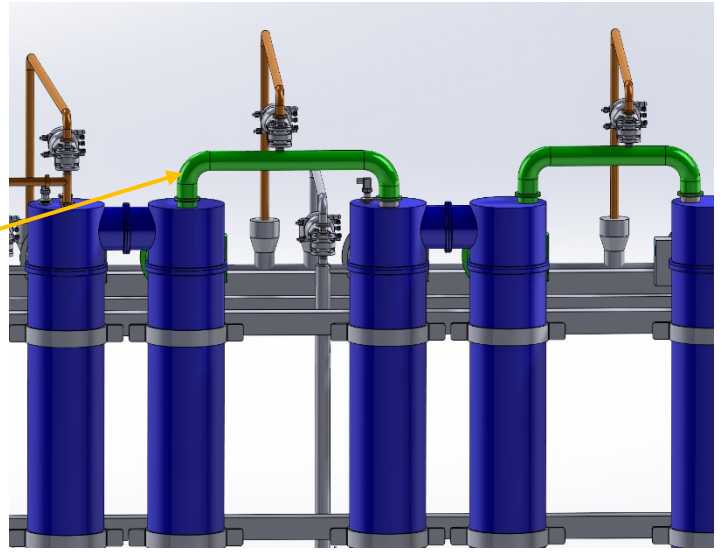
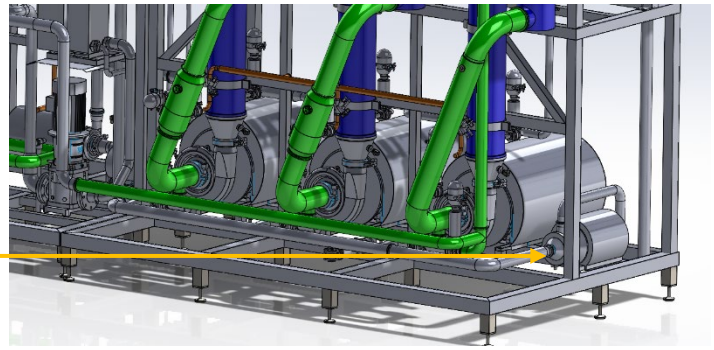
MF1 - Microfiltration 1.4 um

Key design features

- Ceramic MF elements with gradient membranes
- Large pore size 0.8um – 1.4 um
- High crossflow speeds of 5 – 6 m/s
- Operating temperature 50-55 C
- Continuous air removal
- Control of TMP (trans-membrane pressure)
- Efficient phase exchange







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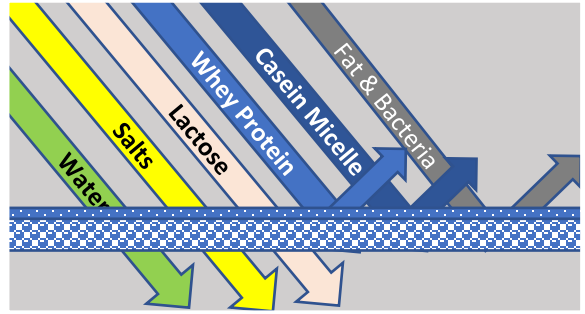
UF1 – Ultrafltration 10kDA

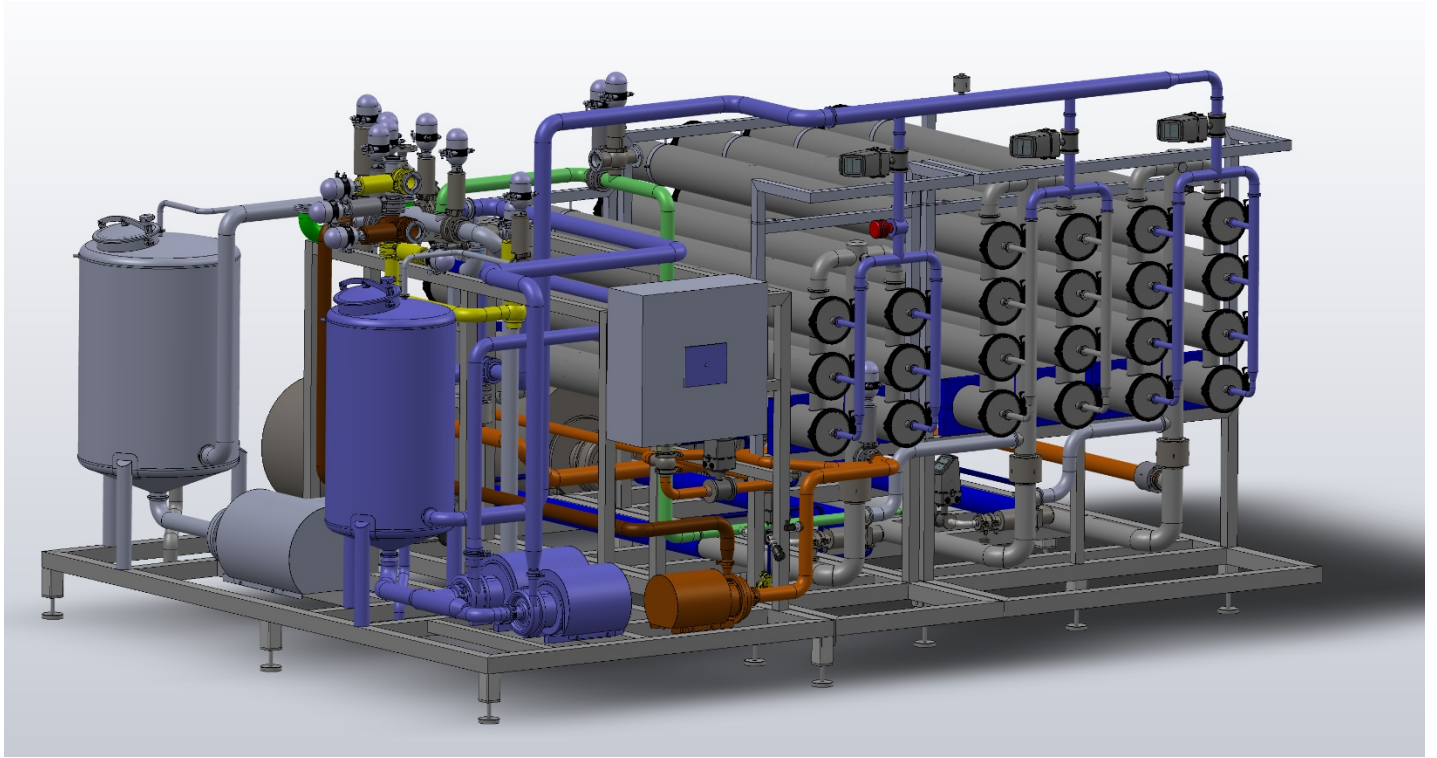
Fractionation of proteins and lactose, salt and water

Pre-concentration of protein prior to MF2 to reduce size of MF2

Removes lactose from protein fraction increasing the milk protein % in milk

Milk Protein Concentrate (MPC 50) production





Key design features

- Spiral wound UF elements
- Crossflow dP of 1.1 -1.3 bar
- Efficient phase exchange with flush valve

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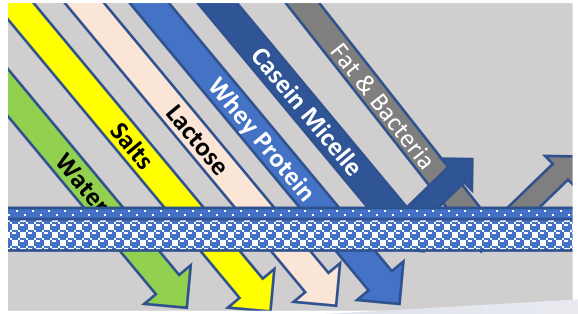
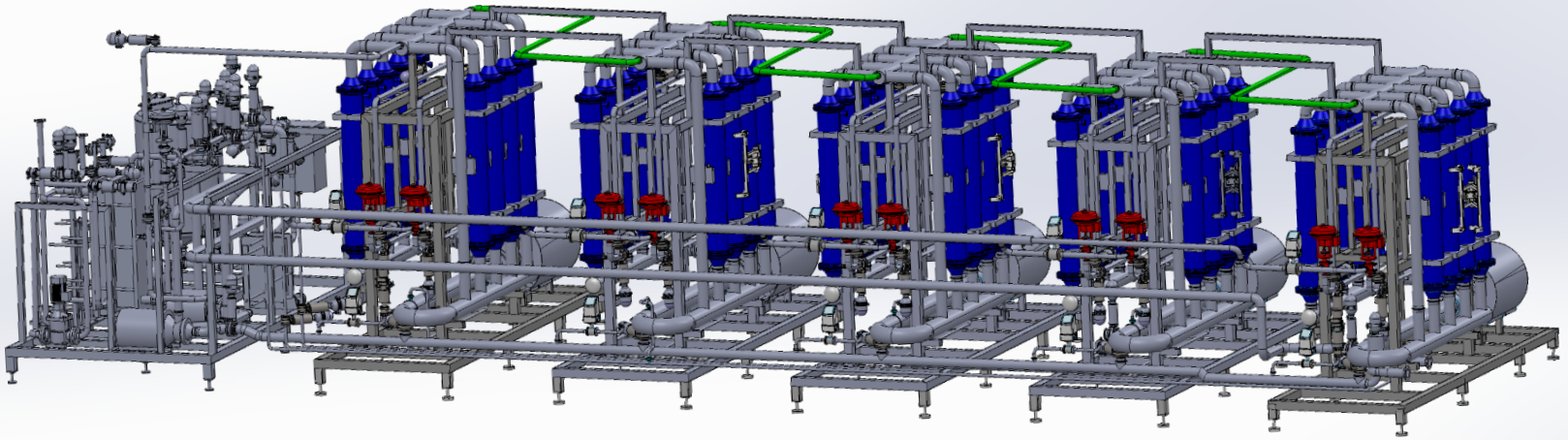
MF2 – Microfiltration 0.2 um

Fractionation of casein and whey protein

- Microfiltration of pore size 0.2 – 0.5 um, retains casein micelles and allows whey protein to pass.
- **Hollow fibre modules** (ceramic and spirals possible with advantages/benefits for both)
- Crossflow dP of 1.0 or 1.5 m/s velocity
- **TMP critical to control** as this defines the gel layer formation on the membrane
- **Continuous air removal**
- **Efficient phase exchange** with drain pump
- Diafiltration optimization





Hollow fibre Microfiltration Unit

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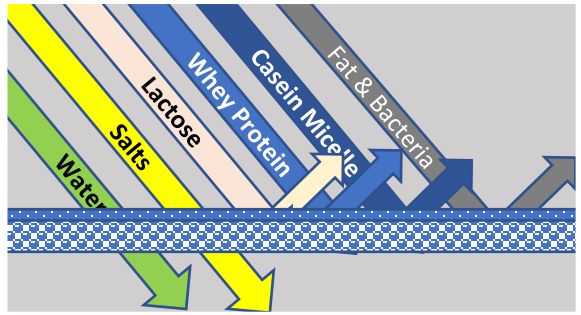
NF – Nanofiltration 100-200DA

Fractionation of lactose from salt and water

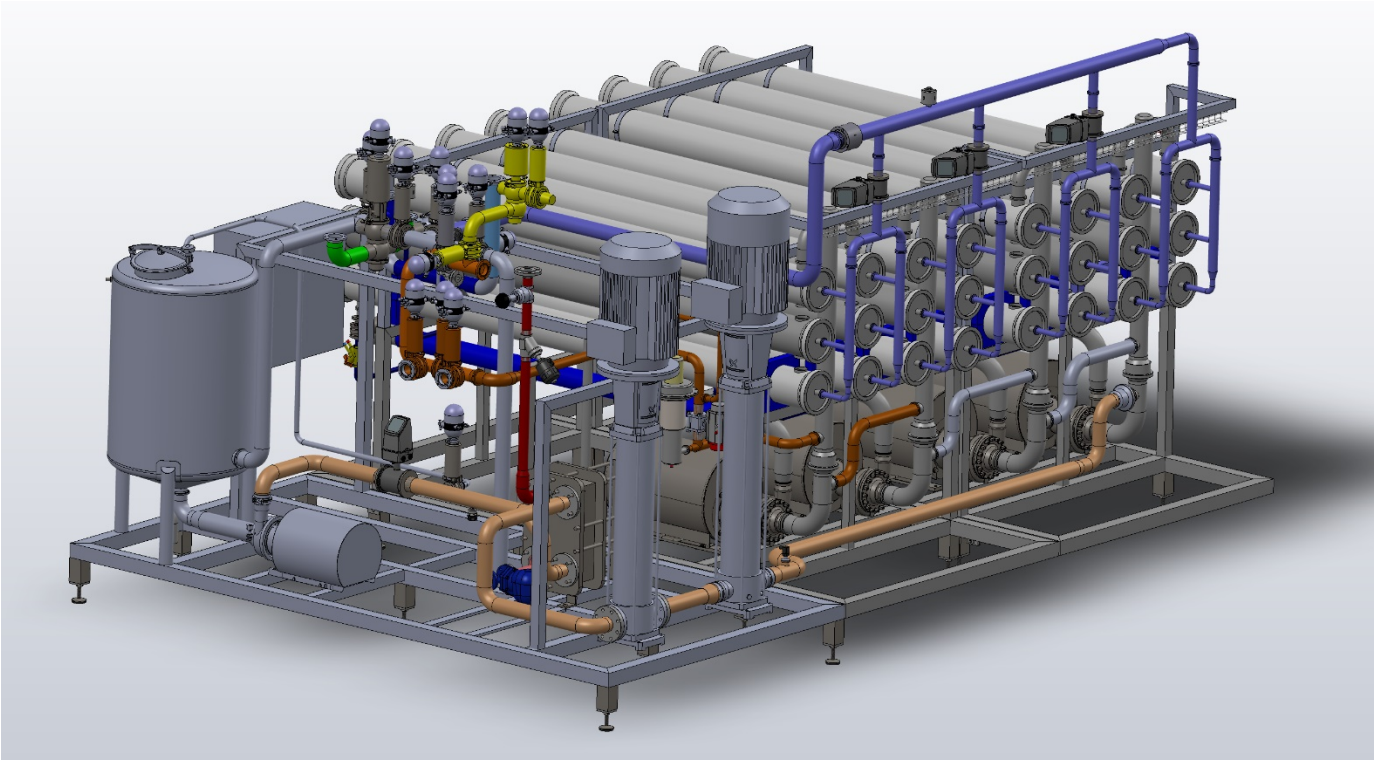
UF permeate as feed

20-24% lactose concentrate



Key design features

- Management of calcium phosphate fall-out
- Spiral wound NF elements (3,4 per housing)
- Crossflow dP of 1.0 -1.1 bar
- Efficient phase exchange with flush valve
- Nr of loops to best optimize usage of membrane area



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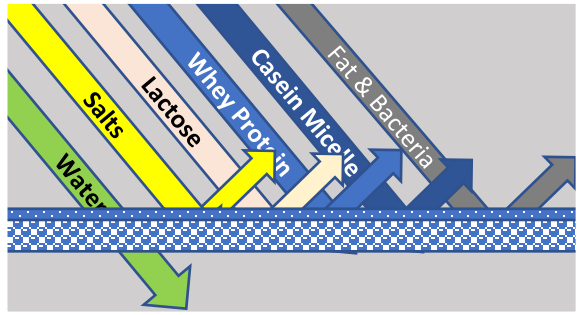
PO – Polisher

Fractionation of salts from water

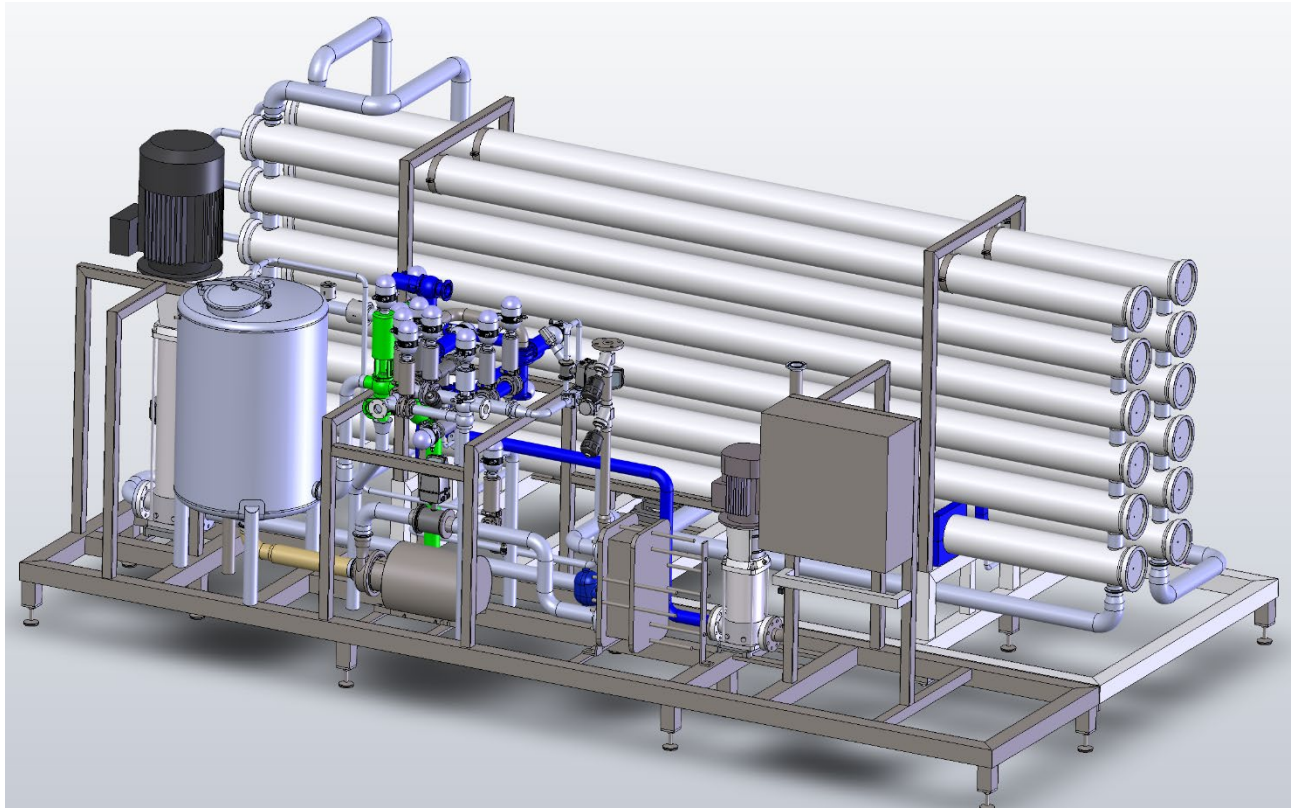
NF permeate as feed

Permeate yield of 90%



Key design features

- Spiral wound RO elements (4,5,6 per housing)
- Crossflow dP of 0.5 – 0.7 bar
- Efficient phase exchange with flush valve
- Nr of loops to best manage quality of permeate



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Milk Fractionation Line

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Fractionation in the Dairy Sector– look to the future

- **Further optimization of whey-casein fractionation**
  - MF2 membrane optimization
  - Design optimization
  - Continuous line operation

- **Further fractionation of whey proteins** into their individual fractions
  - Absorption technology and membranes
  - Cascade membrane technology

- **Higher dry matter concentration** with membranes to reduce evaporation costs
  - Apply knowhow from high viscous lines to MPC, WPC, MCC concentration
  - Apply high system pressure knowhow to lactose concentration

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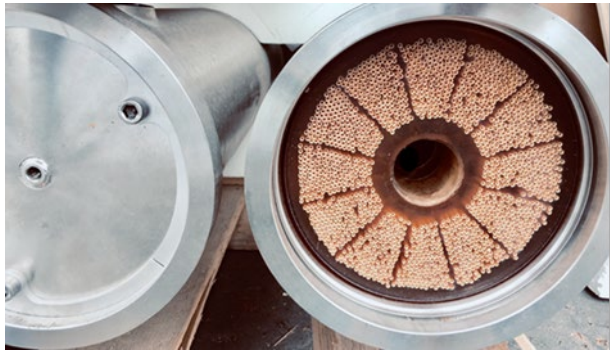
Further optimization of whey-casein fractionation

- Spiral wound modules are continuously being optimized to allow for better fractionation
- The design of the MF units are being optimized to minimise TMP differences
- Hollow fibre module retrofit
- MMS Single housing MF spiral wound modules to operate Spirals “like” hollow fibre and ceramic modules.



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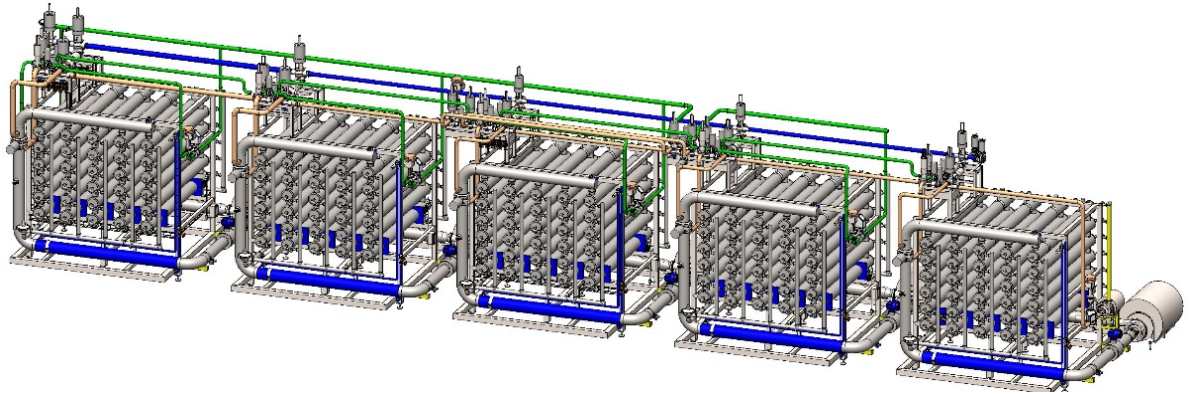
Further optimization of whey-casein fractionation
Continuous line operation

- Spray dryers are the most costly unit operation in a powder line and they operate for many days in row. However, membrane systems need a CIP daily.
- In the micellar casein and native whey line the complexity is increased due to the hot operation of the MF units and cold operation of the UF-NF and RO units.
- Hot operations are operated in time frames of 8-10 hours whilst cold operations up to 20 hrs.
- MMS have developed a concept which allows for 24 hour operation due to an intermediate CIP
  - Reduced time of units
  - Low peak demand of steam and water
  - More effective CIP
  - Smaller buffer tanks
  - Allows other unit operations to operate 24/7



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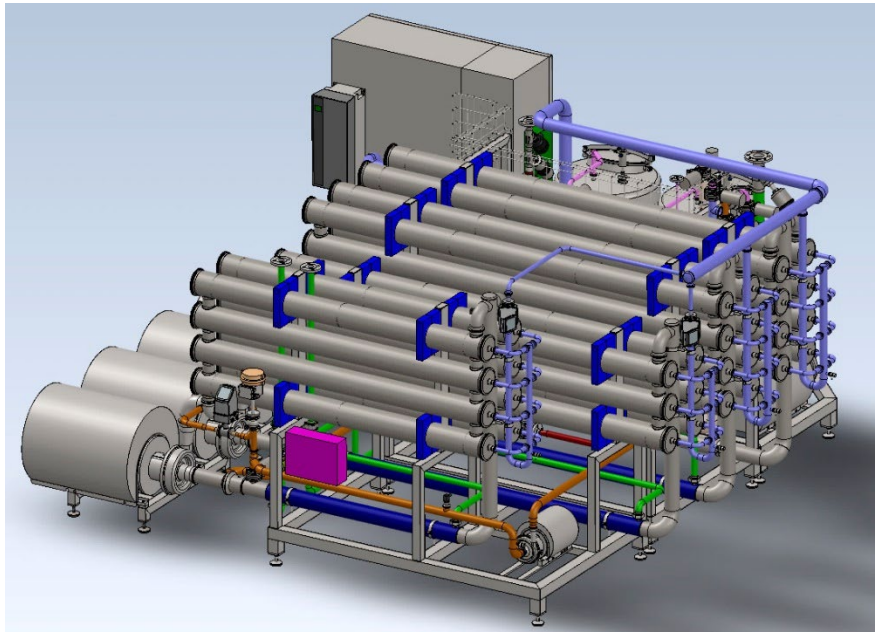
High total solids and high operation pressures

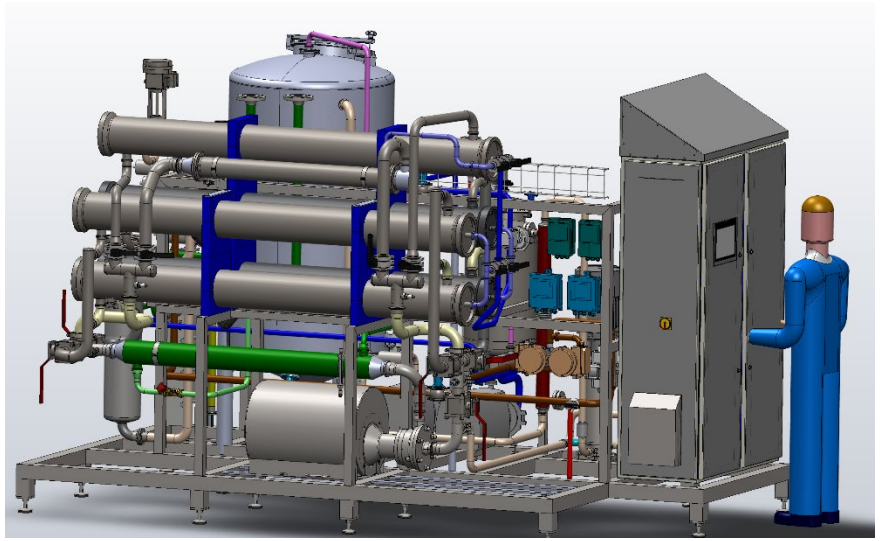
Fractionation of water/lactose from WPC

- Membrane system design to concentrate WPC35/50 to **40% total solids** (and higher) to by-pass eveaporator
- Use knowhow from high viscous product concentration (cream cheese) to whey



Fractionation of sugars from organic acids

- NF selection of membrane to retain sugars and allow lactic acid to pass
- RO – high pressure operation up to **60 bar**. Lactic acid has a high osmotic pressure



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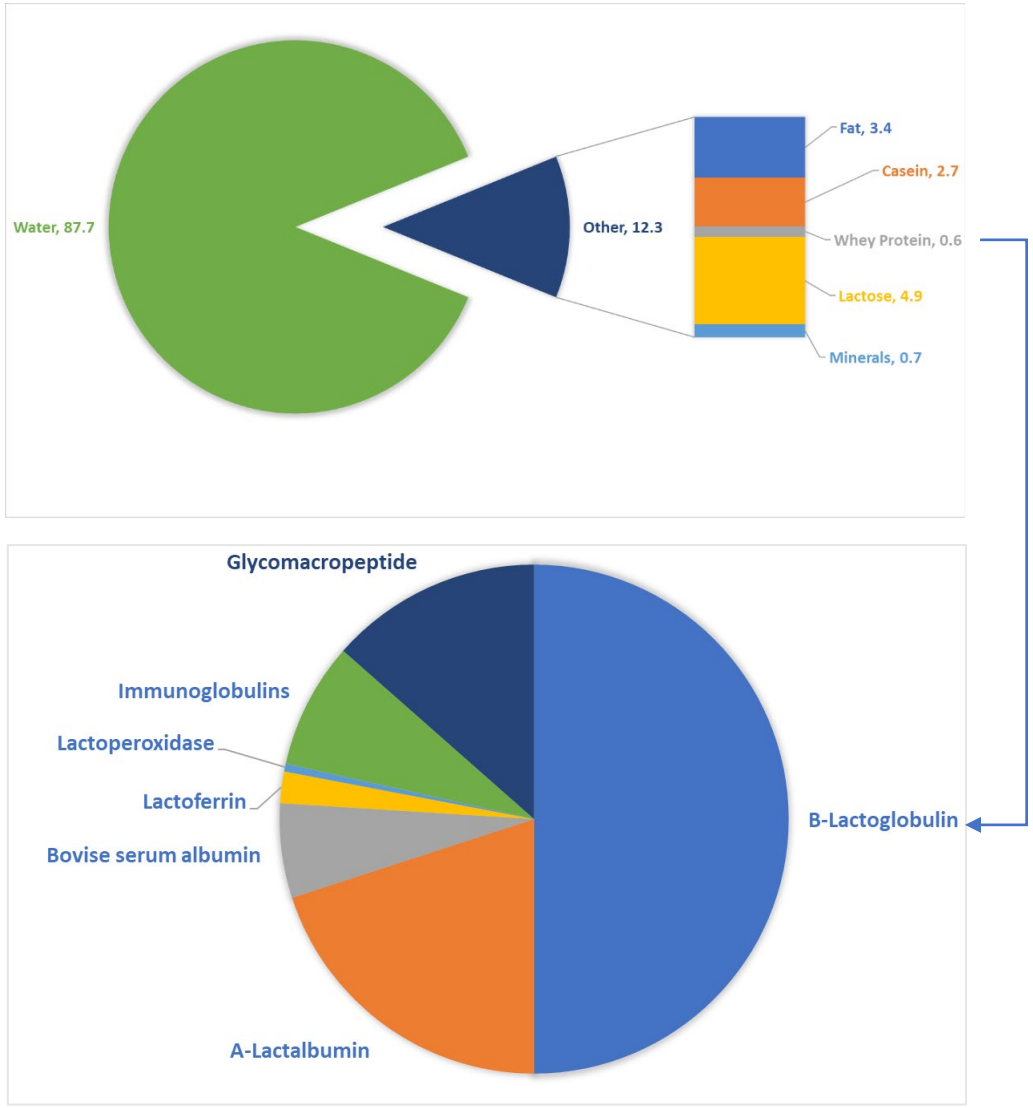
Milk Fractionation - Summary

- Milk fractionation in the dairy sector allows companies to produce MPC, WPC, MCC, lactose and water.
- Membrane technology advantage is that it can separate milk compounds at large scale for a low economic investment.
- Membrane module selection is the first step to designing an effective fractionation line.
- System design and correct operating parameters is the second step.
- Milk fractionation line optimization is on-going through improved membranes and improved system and line designs.
- Further fractionation of milk derivates, such a whey proteins will be next. Membrane technology will compliment absorption technologies, in terms of pre and post treatments.



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Thank you for your attention






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