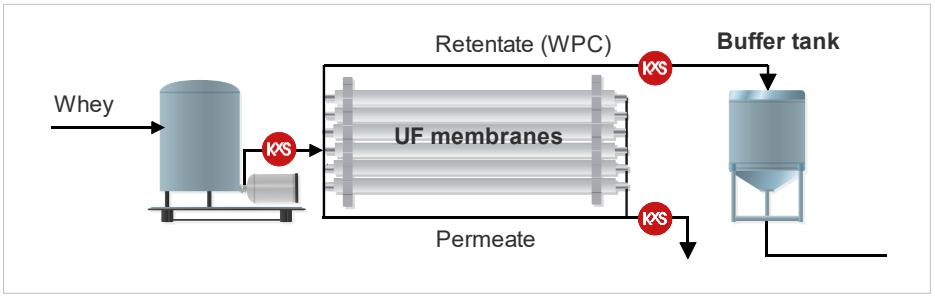
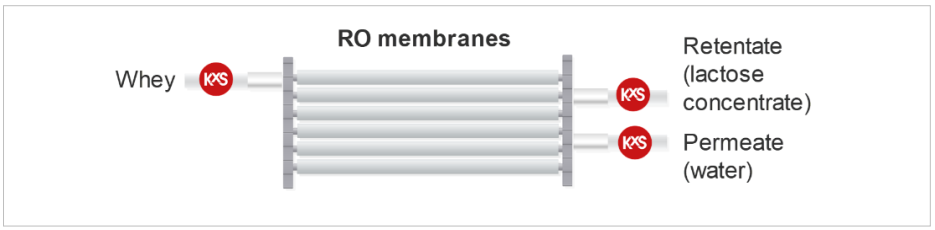
Benefits of R.I. measurement

- Real-time TS% measurement improves membrane filtration efficiency and process stability.
- Optimized concentration endpoint control reduces recirculation time and improves plant throughput.
- Accurate RO concentration control minimizes evaporator energy consumption.
- Real-time monitoring improves whey protein and lactose product consistency.
- KxS DCM-20 can be installed directly in high-pressure RO process lines up to 55 bar (800 psig)
- KxS SFC flow cell provides superior flow velocity on the prism surface, improving the natural self-cleaning effect and reducing fouling.
- Continuous monitoring reduces manual sampling and laboratory workload.





Overview

Membrane filtration is one of the most important separation technologies used in modern dairy processing. It enables efficient concentration, fractionation, purification, and demineralization of milk and whey streams while preserving valuable proteins and lactose.

The process separates a liquid stream into two fractions through a semi-permeable membrane:

- *Retentate* (concentrate) — retained proteins, fats, or larger molecules
- *Permeate* — water, lactose, salts, minerals, and smaller dissolved compounds passing through the membrane

By selecting different membrane pore sizes and operating conditions, dairy producers can concentrate or selectively remove specific components from milk and whey streams.

Refractive index measurement applications

The KxS DCM-20 Process Refractometer provides continuous real-time total solids (TS%) and concentration monitoring throughout membrane filtration processes. Inline concentration measurement allows operators to optimize membrane loading, control concentration endpoints, stabilize product quality and improve downstream process efficiency.

In Ultrafiltration (UF), proteins and fats are concentrated in the retentate phase while lactose, lactic acid and minerals partly leave the process in the permeate stream. UF is widely used for production of Whey Protein Concentrate (WPC), whey powder, cream cheese and fresh cultured cheese products. In whey processing, the first UF step typically concentrates whey by a factor of four to five before subsequent process stages.

Diafiltration (DF) is commonly used together with UF to further purify whey proteins. Water is added to wash out lactose and low molecular weight components through the membrane while proteins are retained. Real-time concentration monitoring enables optimized water addition, reduced process time and improved protein purity.

Nanofiltration (NF) combines concentration and partial demineralization. NF membranes allow small monovalent ions such as sodium and chloride to pass while retaining larger dissolved solids and lactose. In dairy processing, NF improves lactose crystallization efficiency and reduces hygroscopicity of final powders.

Reverse Osmosis (RO) uses very dense membranes operating at high pressures that allow primarily water to permeate. RO is commonly used to pre-concentrate whey prior to evaporation in order to reduce overall energy consumption and increase plant capacity.

Whey protein and lactose production

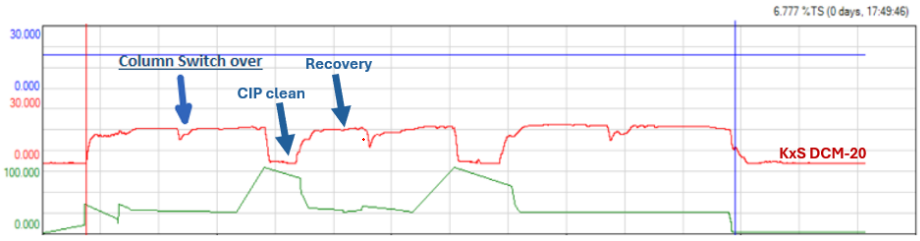
Whey is the liquid residue from cheese and casein production and contains a significant amount of valuable food protein. Whey typically represents 80–90% of the original milk volume and contains approximately half of the nutrients originally present in milk, including proteins, lactose, minerals and vitamins.

During whey protein production, the process usually starts with removal of fines and fat, followed by Ultrafiltration. In UF, proteins are retained in the retentate while lactose-rich permeate passes through the membrane. The whey protein retentate is further concentrated and eventually dried into powder. The permeate stream is often concentrated by evaporation before lactose crystallization and drying.

To achieve whey protein concentrations above 80%, diafiltration is used to wash out lactose and salts from the retentate. In lactose production, concentrated whey is transferred to crystallizers where seed crystals are added to initiate lactose crystallization before centrifugation and drying.

Lactose RO trend case

The trend (see image) illustrates stable TS% measurement performance during normal production, column changeovers and repeated CIP cleaning cycles. After each operational disturbance, the refractometer signal rapidly returns to baseline conditions without drift, demonstrating long-term stability and reliable lactose concentration control in continuous RO operation.



Instrumentation and installation considerations

In membrane filtration processes, the retentate or concentrate outlet is typically the most valuable installation point because it represents the actual product concentration generated by the membrane separation process. Measuring the concentrate stream allows direct control of protein or lactose concentration, membrane loading, downstream evaporation efficiency and process endpoint. Permeate measurement is typically optional and mainly used for membrane leakage detection and membrane integrity monitoring.

Unlike many traditional refractometers used in Reverse Osmosis applications, the KxS DCM-20 can be mounted directly in high-pressure RO process lines due to its robust hygienic construction and pressure resistance up to 55 bar (800 psig). This allows true inline installation directly in the process instead of outside the circulation loop, resulting in easy mounting, faster response and improved process visibility.

Continuous inline measurement also captures real process fluctuations and concentration peaks that periodic laboratory sampling may completely miss.

The KxS DCM-20 is also strong in low concentration applications where traditional refractometers may drift near water-like conditions. This is especially important in whey permeate monitoring and low dissolved solids applications where accurate measurement performance close to zero TS% is required.

SFC flow cell installation is non-negotiable for reliable performance

KxS is the only refractometer on the market that offers the unique SFC flow cell innovation, which offers superior flow conditions compared to traditional outer pipe bend and T-piece installations.

In whey and lactose membrane filtration processes, maintaining proper flow across the prism surface is essential for stable and reliable measurement performance. Proteins, fats and lactose crystals can easily create coating and fouling on poorly designed installations where the local flow velocity on the prism is insufficient.

Traditional outer pipe bend installations often suffer from unstable flow patterns, low local velocity, dead zones and limited self-cleaning effect. Suitable installation bends may also be difficult to find and access for maintenance.

The KxS SFC flow cell is designed to maximize laminar flow directly across the prism surface, significantly improving the natural self-cleaning effect and minimizing coating formation. This results in a more stable measurement signal, faster response time and improved long-term reliability even in demanding whey and lactose processing applications.

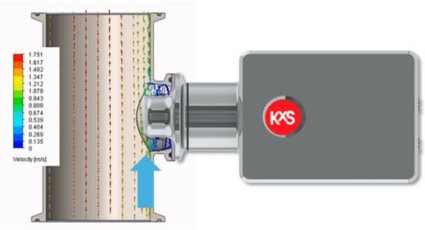
Field experience has shown that proper flow conditions are one of the key factors behind stable refractometer performance in membrane filtration processes. The KxS SFC flow cell provides significantly higher and more controlled flow velocity on the prism compared to conventional elbow-mounted and T-piece solutions.

In most dairy applications, the natural process flow together with regular CIP cleaning is sufficient to keep the prism clean and maintain reliable operation without additional cleaning systems.

Traditional T-piece flow cell:

Consequences of improper installation: Flow velocity too low—fouling on prism

Flow on prism 0.5 m/s

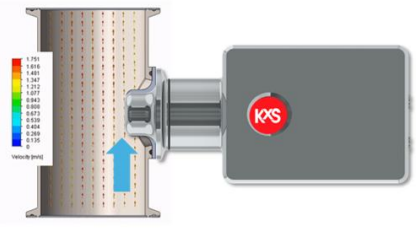


Flow 1.5 m/s

SFC flow cell:

Best laminar flow = Keeps optical window clean and signal stable
Best hygienity = Minimizes dead spaces and risk of contamination

Flow on prism 1.2 m/s



Flow 1.5 m/s