

Pilot-Scale Molecular Separation containerized skid

The TNO Pilot-Scale Molecular Separation Unit is a groundbreaking innovation designed to perform three distinct membrane separation processes, making it the only unit of its kind globally. This system represents a major leap forward in the field of molecular separation, offering unparalleled versatility and adherence to the highest safety standards.

This is a portable pilot-scale system designed to be accommodated within a purpose-built container, facilitating on-site or remote demonstrations of targeted membrane process. Specifically engineered to support the



separation of liquid solvents, this adaptable system allows users to tailor it to their unique separation requirements effortlessly. The versatility of the system enables testing of membranes across various modules, providing a comprehensive assessment of their stability and performance in separation processes. A key feature of the system is its capability to operate in three distinct membrane process, enhancing its flexibility and applicability.

The membrane separation processes that can be carried out using this pilot-scale plant are as follows:

1. Pervaporation: This is a separation process in which a liquid mixture is introduced to a selective membrane, allowing certain components to selectively vaporize and permeate through the membrane. This process is commonly used for the separation of organic liquid mixtures, particularly in the dehydration of organics.
2. Vapor Permeation: In this process, feed is introduced to the membrane housing in vapor phase instead of liquid, and membrane selectively separates the vapor components.
3. Nanofiltration: This is a pressure-driven membrane separation process that can separate small molecules in the range of 300 to 2000 Dalton from an aqueous or organic mixture. The driving force is the pressure gradient across the membrane and this Molecular Separation Unit can operate under up to 10 bars of pressure.

The Molecular Separation Unit can separate components of an organic mixture from each other on a molecular level. Typical applications are, but not limited to:

- Dewatering of solvents (e.g., ethanol, IPA, THF, acetonitrile, MEK, ethyl acetate, NMP, etc.)
- Dehydration of solvents and organic acids (e.g. acetic acid, acrylic acid, succinic acid)
- Methanol/dimethyl carbonate (MeOH/DMC) separation
- Breaking azeotropes
- Separation of volatile organic compounds from an organic mixture
- In-situ dehydration during reactions (e.g. esterification reactions)

- Debottlenecking of distillation processes
- Separating lower molecular weight solvents from higher molecular weight solvents

Pervaporation, vapor permeation, and nanofiltration membrane processes find their application within the chemical industry, the food and beverage industry, bio processing, and the pharmaceutical industry. These processes contribute to energy saving and reduction of CO₂ footprint and circularity in industry.

The unit is built on a modular red stainless steel frame, providing flexibility and ease of maintenance. This steel frame is placed in a 20 ft container, facilitating mobility. Thanks to its easy transportation, it can be deployed to various industrial locations around the world. The Unit consists of all process equipment of a full-scale separation plant such as Feed Pump, Membrane Housing, Electrical Cabinet, Permeate Vessel, and a Shell & Tube Permeate Condenser.



Operated seamlessly by TNO personnel on a continuous 24/7 basis, the system is equipped with integrated emergency controls to swiftly respond to unforeseen situations. The Human Machine Interface (HMI) empowers precise control and setpoint adjustments tailored to customer requirements.

To ensure secure and reliable operation while adhering to the highest safety standards and regulations, the pilot unit incorporates several safety features. The system is fully compliant with ATEX standards, ensuring safe operation in potentially explosive atmospheres. The system bears CE certification, attesting to its conformity with European Union safety requirements. Leak trays are in place to capture any potential spills or leaks, preventing environmental contamination. Safety valves and alarms provide early warnings and additional layers of protection.

In summary, the Pilot-Scale Molecular Separation Unit represents a cutting-edge development that marries versatility with safety. Its ability to perform three distinct membrane separation processes, coupled with its modular design and robust safety features, positions it at the forefront of molecular separation technology.

Operational and design parameters:

The Pilot-Scale Molecular Separation Unit is designed for operation with TNO 1 m² HybSi[®] isothermal pilot-scale module. Provision will be made to accommodate others including but not limited to:

- Deltamem 5 m² PERVAP[™] Pilot module
- Pervatech 0.1 m² PVM-050-10-A module

The pilot unit is designed for operation under the following operational conditions:

- Max feed flow rate: 500 kg/h
- Max permeate capacity: 20 kg/h
- Maximum temperature: 180°C
- Maximum pressure: 10 bar

Infrastructure Factsheet



The Pilot-Scale Molecular Separation Unit is designed for operation with the following utilities:

- Thermal oil or steam for heating
- Cooling water or glycol for cooling
- Nitrogen for purging and inerting
- Instrument air

Utilities can be used with the following specifications:

- Steam 58 kg/h at 9 bar at 180 °C
- Cooling water 2,8 m³/h at 2.5 bar at 25 °C
- Glycol cooler 6,4 m³/h at 2 bar at -10 °C
- Nitrogen 15 kg/h for dry out at 3 bar
- Instrument Air 5 bar at 25 °C

The plant is suitable for installation and operation in a Zone 1 hazardous area.

ATEX compliance: ATEX Zone 1 Internally and externally, Group IIB, Temperature Class T4.

Material SS316L

Dimensions 5*2,5*2,6m (L*W*H)

Weight 7500 kg