



Membrane Technology for Gas Processing Basics & Applications

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- 1 Principles of Gas Separation by Membranes
- 2 Membranes & Modules
- 3 Industrial Applications - Overview
- 4 References



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1 Principles of Gas Separation by Membranes

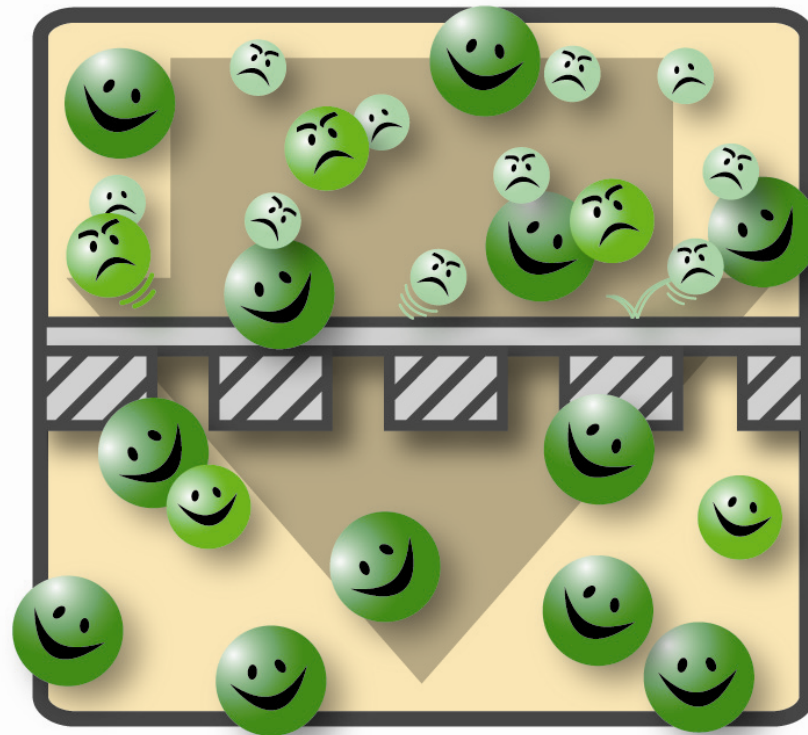
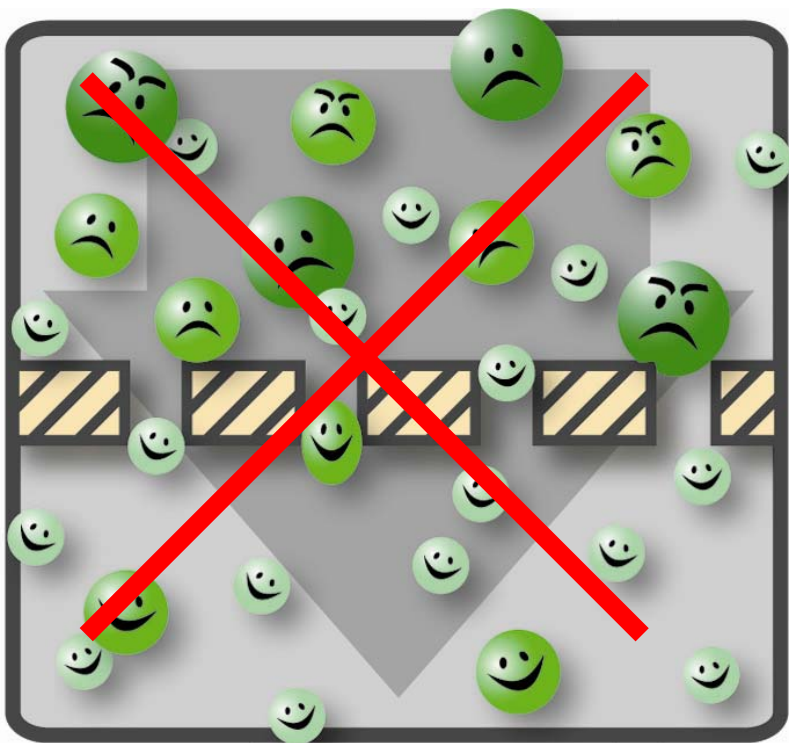
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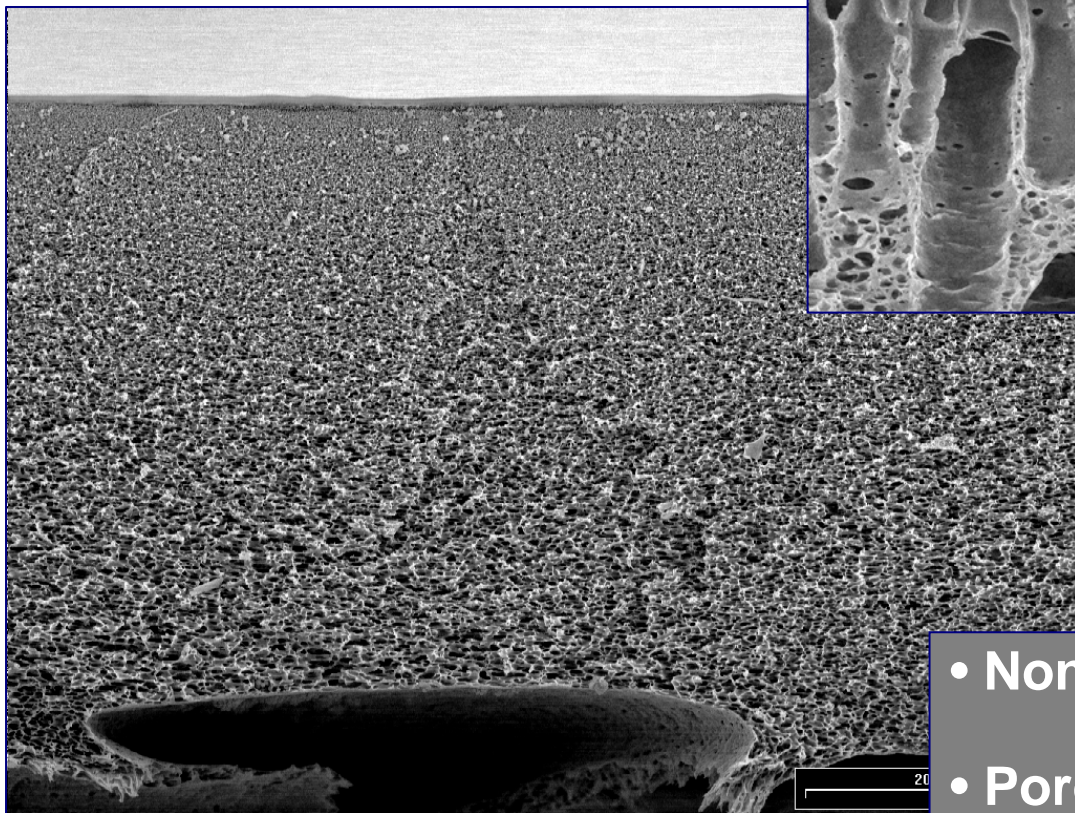
Principles of Gas Separation by Membranes - Transport Model



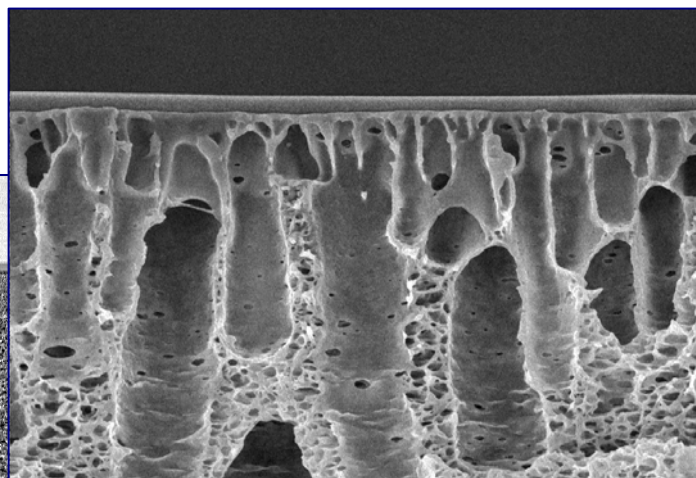


Principles of Gas Separation by Membranes - Dense Composite Membranes

20 μm



Composite membrane



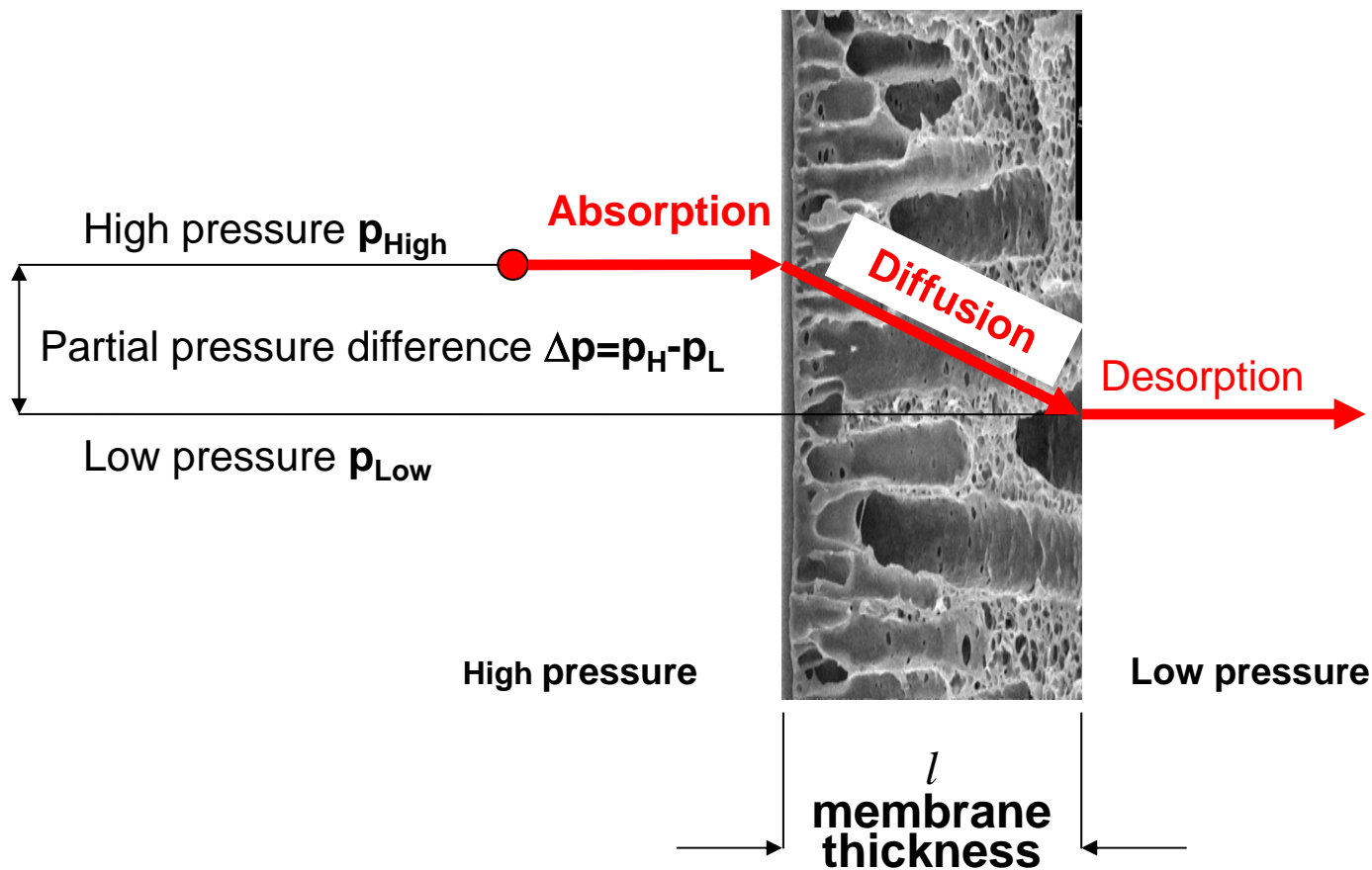
7 μm

Composite membrane

- Non porous selective layer
- Porous substructure



Principles of Gas Separation by Membranes - Solution/Diffusion Model



Transport Steps:

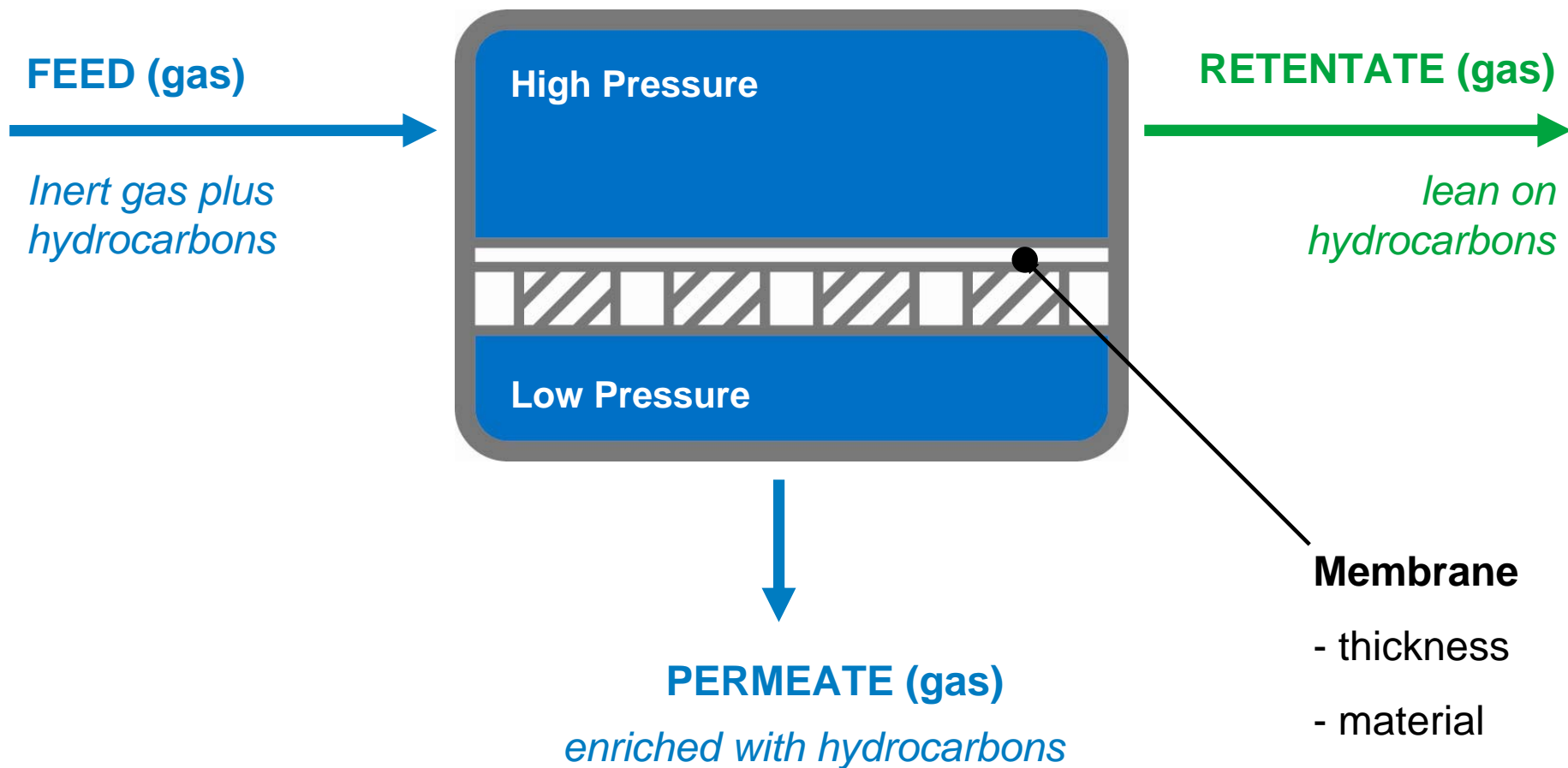
- 1) Absorption into the polymer matrix on the membrane surface
- 2) Diffusion of the dissolved gas through the membrane
- 3) Desorption from the membrane back side

Transport Parameter:

- 1) Solubility
- 2) Diffusion Coefficient

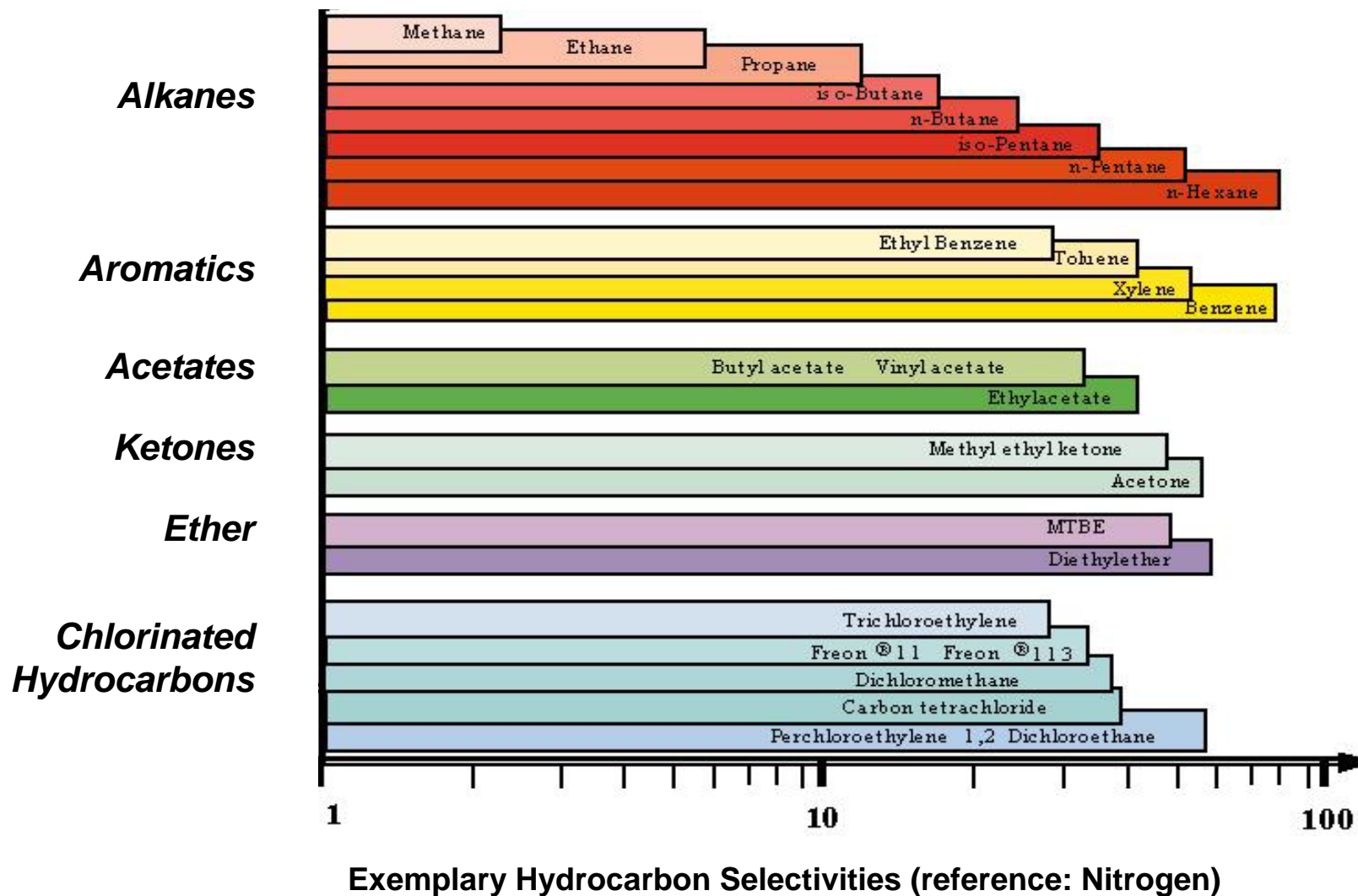


Principles of Gas Separation by Membranes - Nominations





Principles of Gas Separation by Membranes - Selectivities





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Membranes & Modules - Flat membrane configured as envelope or spiral wound type



Flat Membrane Production



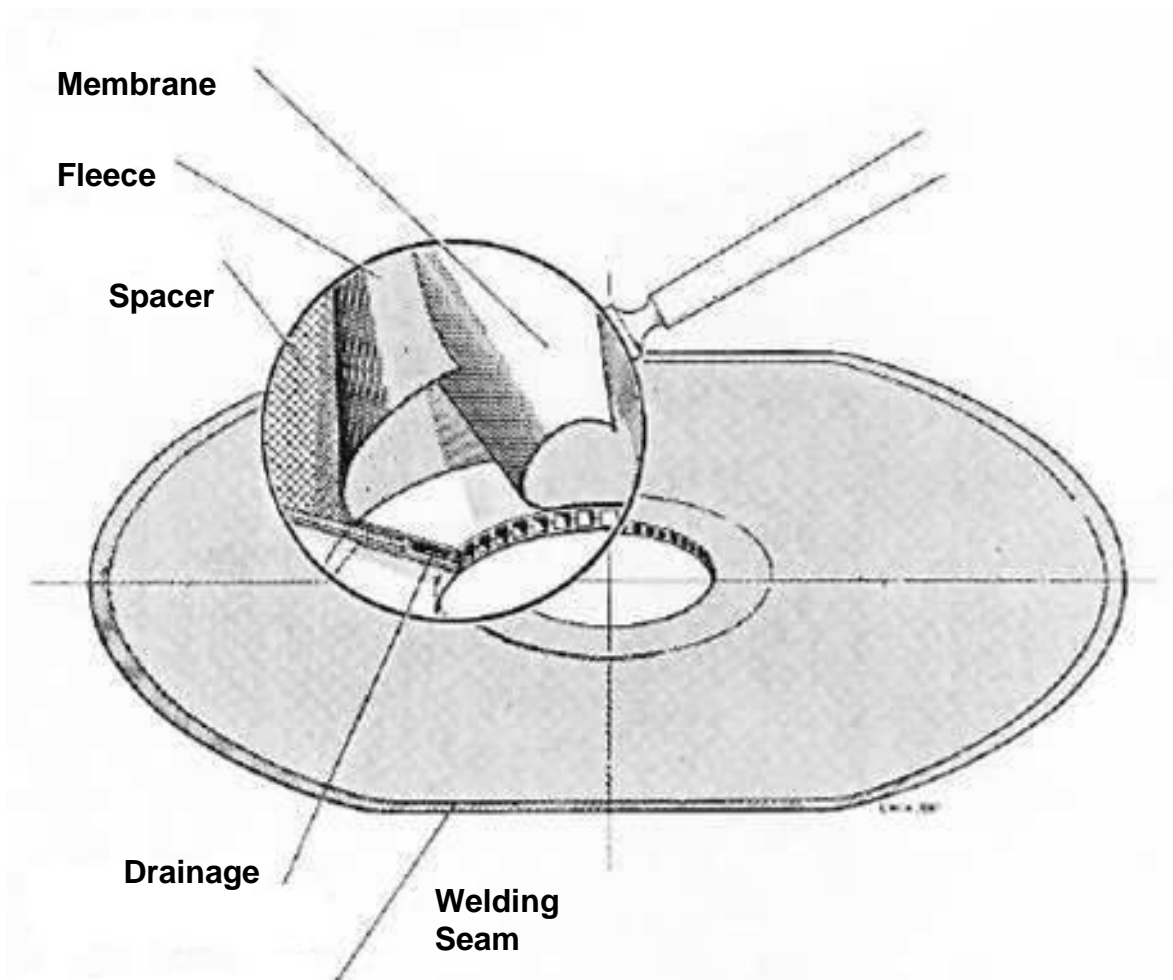
Envelope Production

Module Packing



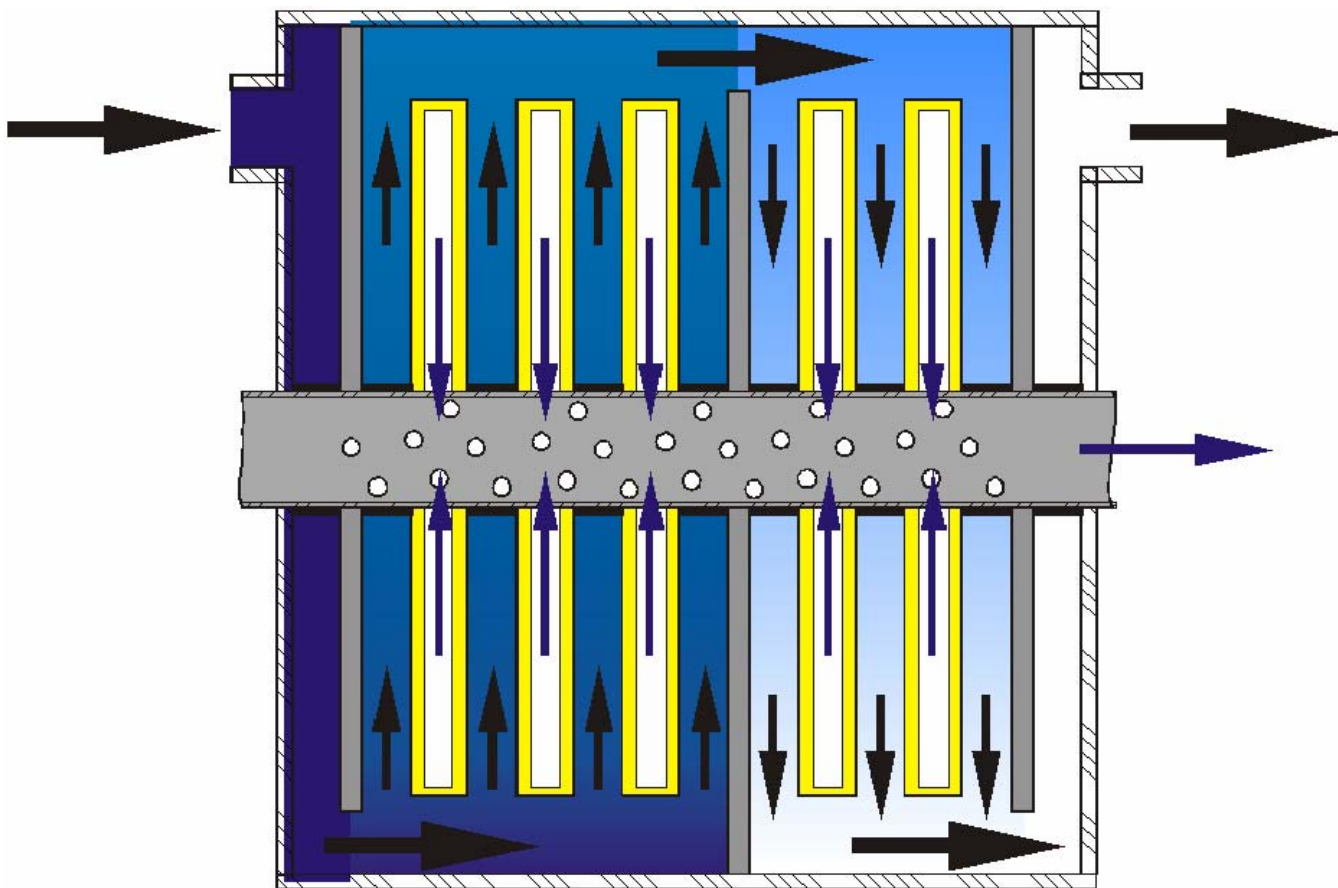


Membranes & Modules - Flat membrane configured as envelope type





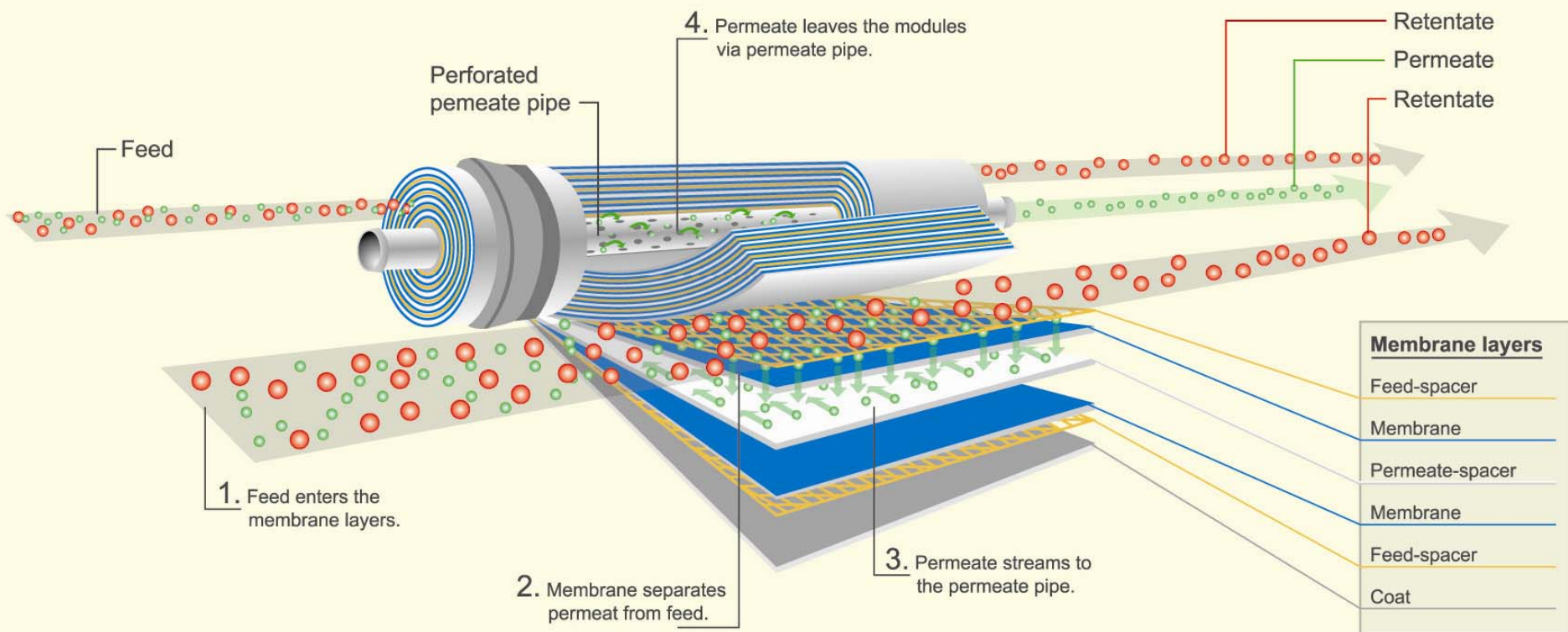
Membranes & Modules - Flat membrane configured as envelope type





Membranes & Modules - Flat membrane configured as spiral wound

Structure and function of a spiral wound module





Membranes & Modules - Typical Module Arrangement

- ✓ **Modular system**
- ✓ **Tailored performance**
- ✓ **Easy to change / expand**
- ✓ **Galvanised steel support**
- ✓ **Long lifetime**
- ✓ **Best performance**
- ✓ **Outdoor skid installation or**
- ✓ **Container design incl. heating**

- ✓ **Stainless Steel Modules**
- ✓ **Aluminium Alloy Modules**



Outdoor Borsig Membrane Separation Unit
with 4 Modules and one Spare Place



Membranes & Modules - Typical Module Arrangement in Container



Inside view of a container-based membrane unit



Membrane container in petrochemical plant



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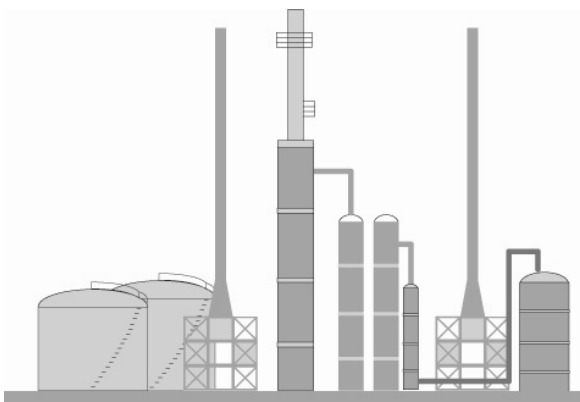
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Applications – Flexible Treatment of many Hydrocarbons

Flexible Solutions for various Hydrocarbons:



VOS's / Hydrocarbon Vapours

from

Production, Storage & Distribution

(typically mixed with inert gas or air)

*solvents, gasoline, additives, ETBE, MTBE, reformate, gas oil, solvent naphta, crude vapours, LPG, associated gas, ethane, propane, butane, pentane, hexane, cyclo-hexane, heptane, other paraffins, ethylene, propylene, butene, methanol, ethanol, propanol, butanol, aldehydes, aromatics (BTX), benzene, toluene, xylene, ethylacetate, vinylacetate, butyl- acetate, acrylates, dimethylether, propylene oxide, halogenated hydrocarbons like 3-chloro-fluor-methane (R22), vinylchloride, tetrachloroethylene, acetone, MEK cyclo hexanone, VCM, acrylnitrile, acetonitrile, cyc5-diene
.....and many more!*



PETROCHEMICAL / CHEMICAL

FUEL GAS CONDITIONING

EMISSION CONTROL

SERVICES





Applications – Petrochemical / Chemical

PETROCHEMICAL / CHEMICAL

FUEL GAS CONDITIONING

EMISSION CONTROL

SERVICES

**Membrane Separation Units for
Hydrocarbon Separation in Gas/Vapour Streams**

**VOC / Hydrocarbon Vapour Recovery Units for
Aromatics (BTX), Methanol, Ethanol, MTBE etc.**

**Propylene Monomer Recovery Units for the
Production of Poly Propylene (PP)**

**Ethylene Monomer Recovery Units for the
Production of Ethylene Oxide (EO)**

Vinyl Chloride Monomer (VCM) Recovery Units

**Ethylene Monomer Recovery Units for the
Production of Vinyl Acetate (VAM)**



Applications – Fuel Gas Conditioning

PETROCHEMICAL / CHEMICAL

FUEL GAS CONDITIONING

EMISSION CONTROL

SERVICES

NGL Recovery Units

Fuel Gas Treatment for Gas Engines or Turbines

Gas Conditioning for Exploration Sites



Applications – Emission Control

PETROCHEMICAL / CHEMICAL

FUEL GAS CONDITIONING

EMISSION CONTROL

SERVICES

Vapour Recovery Units for Terminals & Refineries

Vapour Recovery Units for Marine Loading

Gas Balancing & Gasholder Systems
for Vapour Recovery Installations

Emission Control Systems for Petrol Stations

Retrofit Kits for Active Carbon Units



Applications – Services – BORSIG the Partner for your complete Project!

PETROCHEMICAL / CHEMICAL

FUEL GAS CONDITIONING

EMISSION CONTROL

SERVICES

Feasibility & HAZOP Studies

**Process Simulation & Development
Analysis & Optimisation**

Basic & Detail Engineering

Support for Authority Approvals

Erection, Commissioning & Training

Performance Tests and Emission Measurements

**Maintenance & Trouble Shooting
Stand-by Service & Remote Service**

Spare Part Management

**Retrofit of existing
“non-membrane-type” VRU Systems**



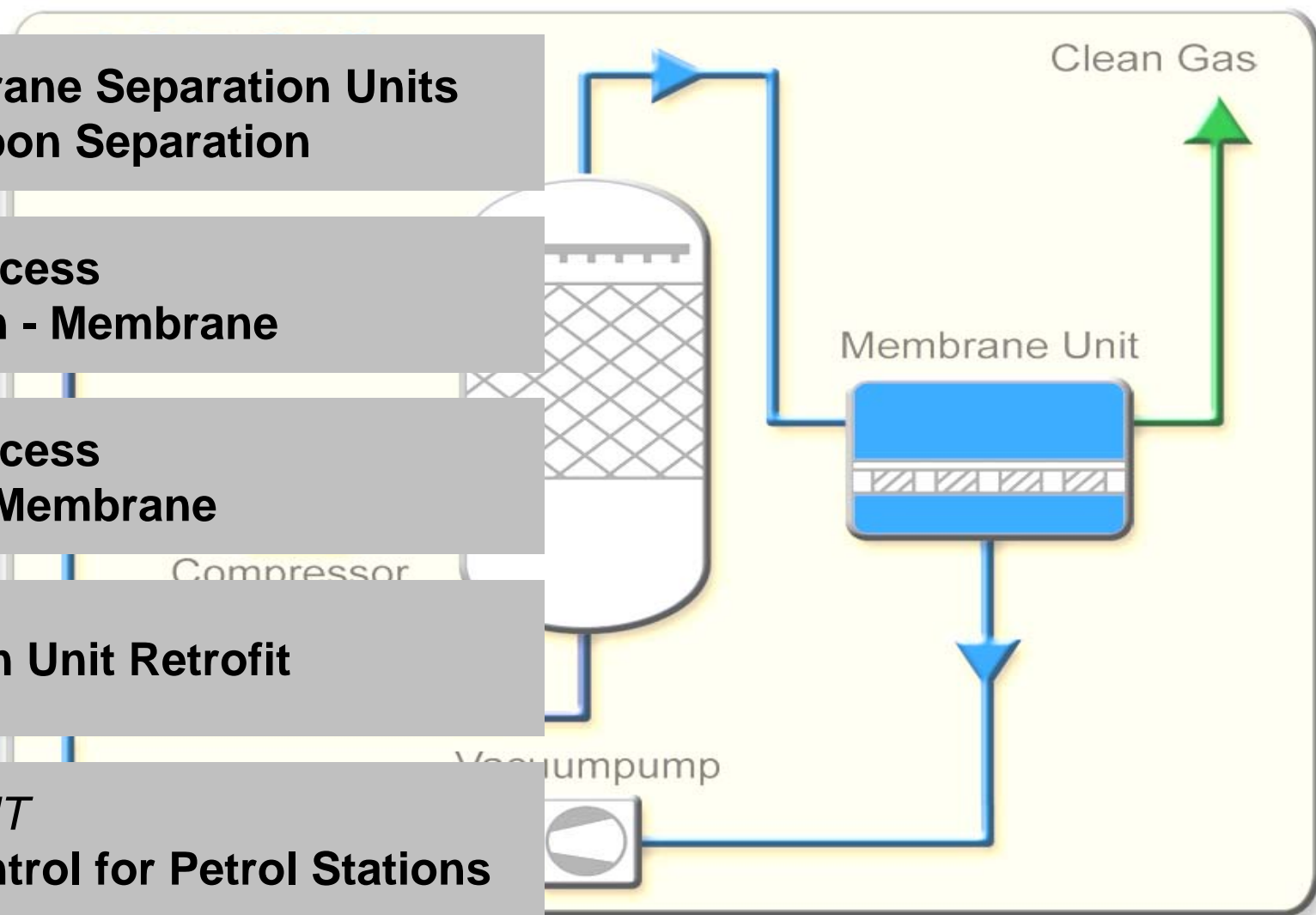
**Single Membrane Separation Units
for Hydrocarbon Separation**

**Recovery Process
Condensation - Membrane**

**Recovery Process
Absorption - Membrane**

Active Carbon Unit Retrofit

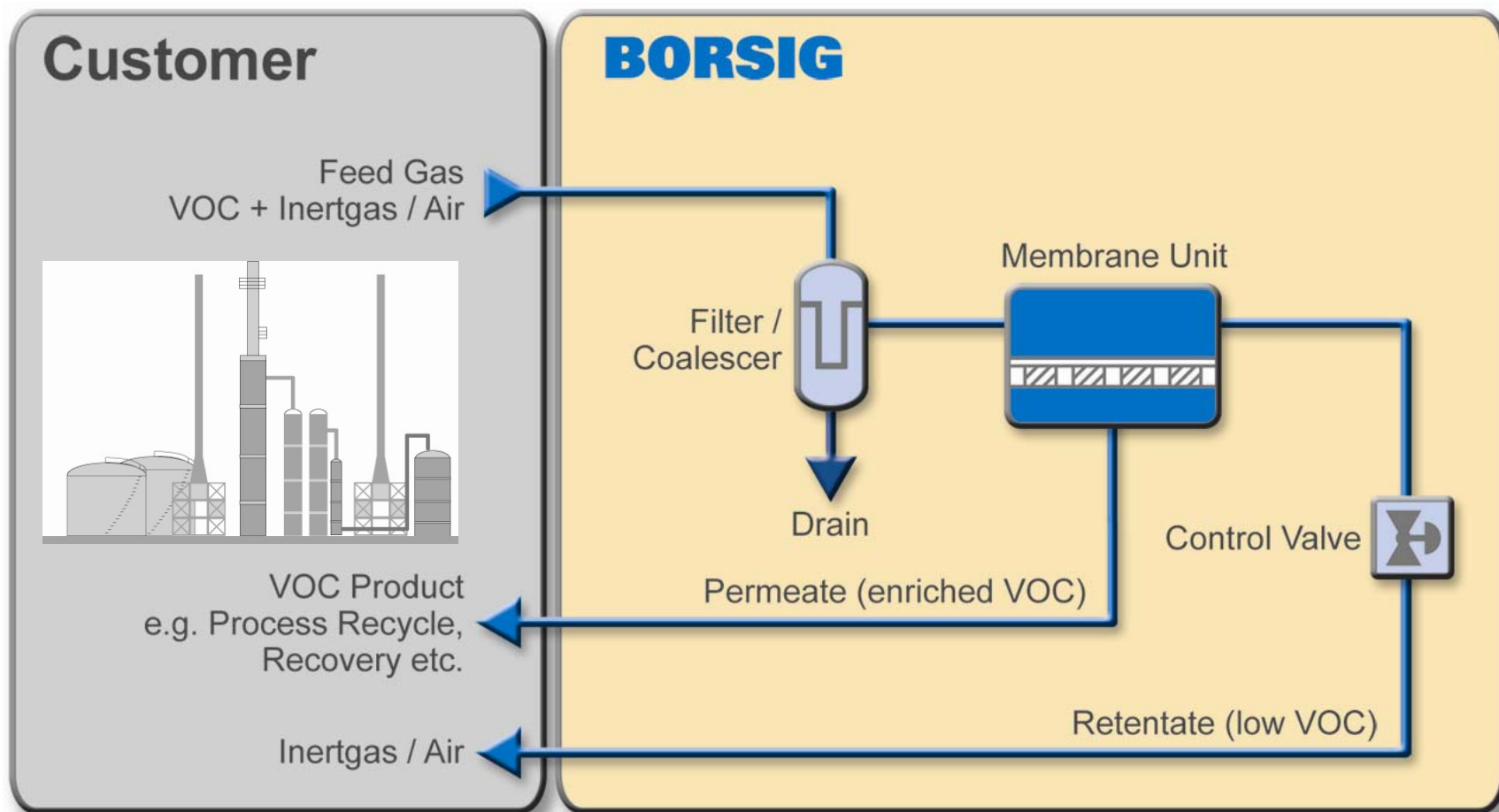
**VACONOVENT
Emission Control for Petrol Stations**





Applications - Process “Membrane Separation Unit”

Membrane Separation Unit for Process Integration

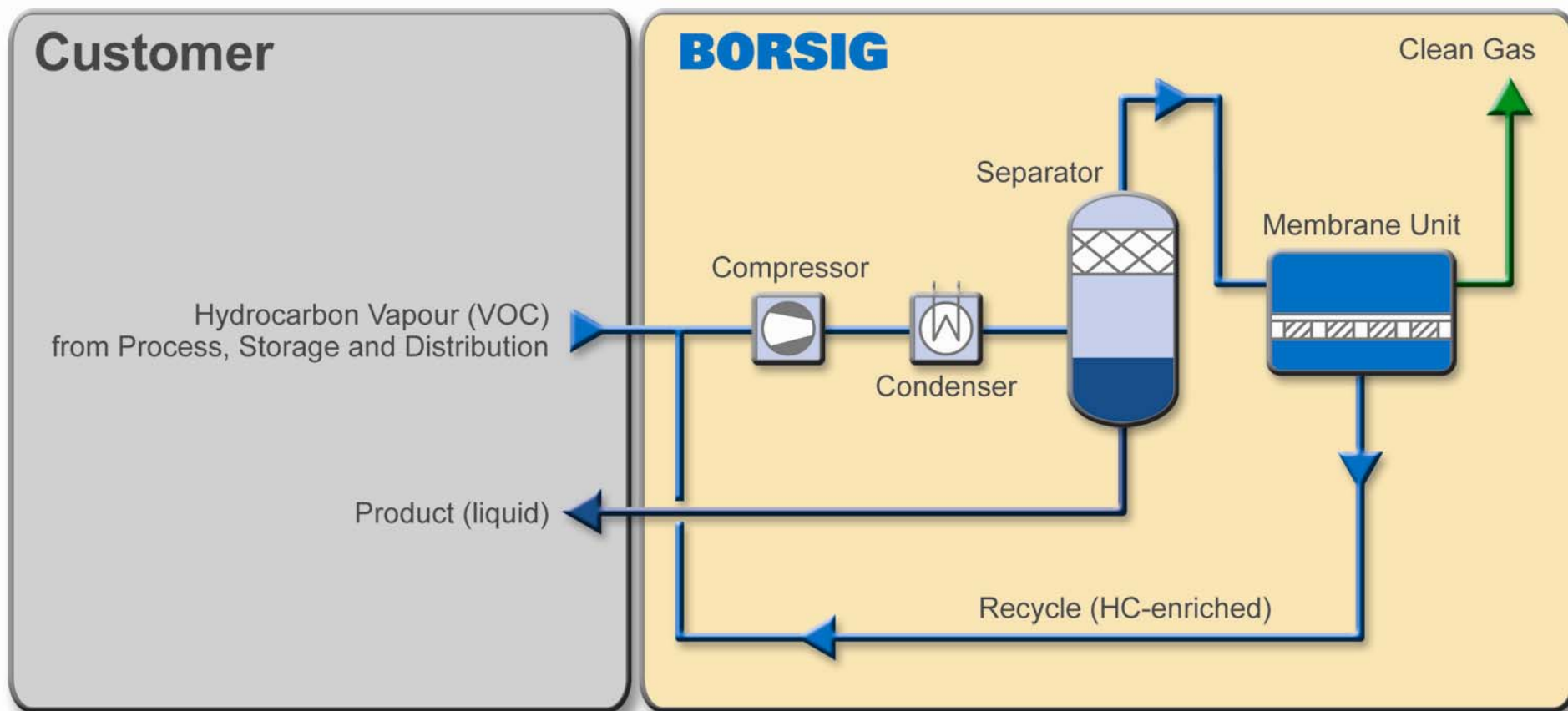


Membrane Separation Unit



Applications – Process “Condensation / Membrane Separation”

BORSIG Recovery Process with Membrane Separation Unit

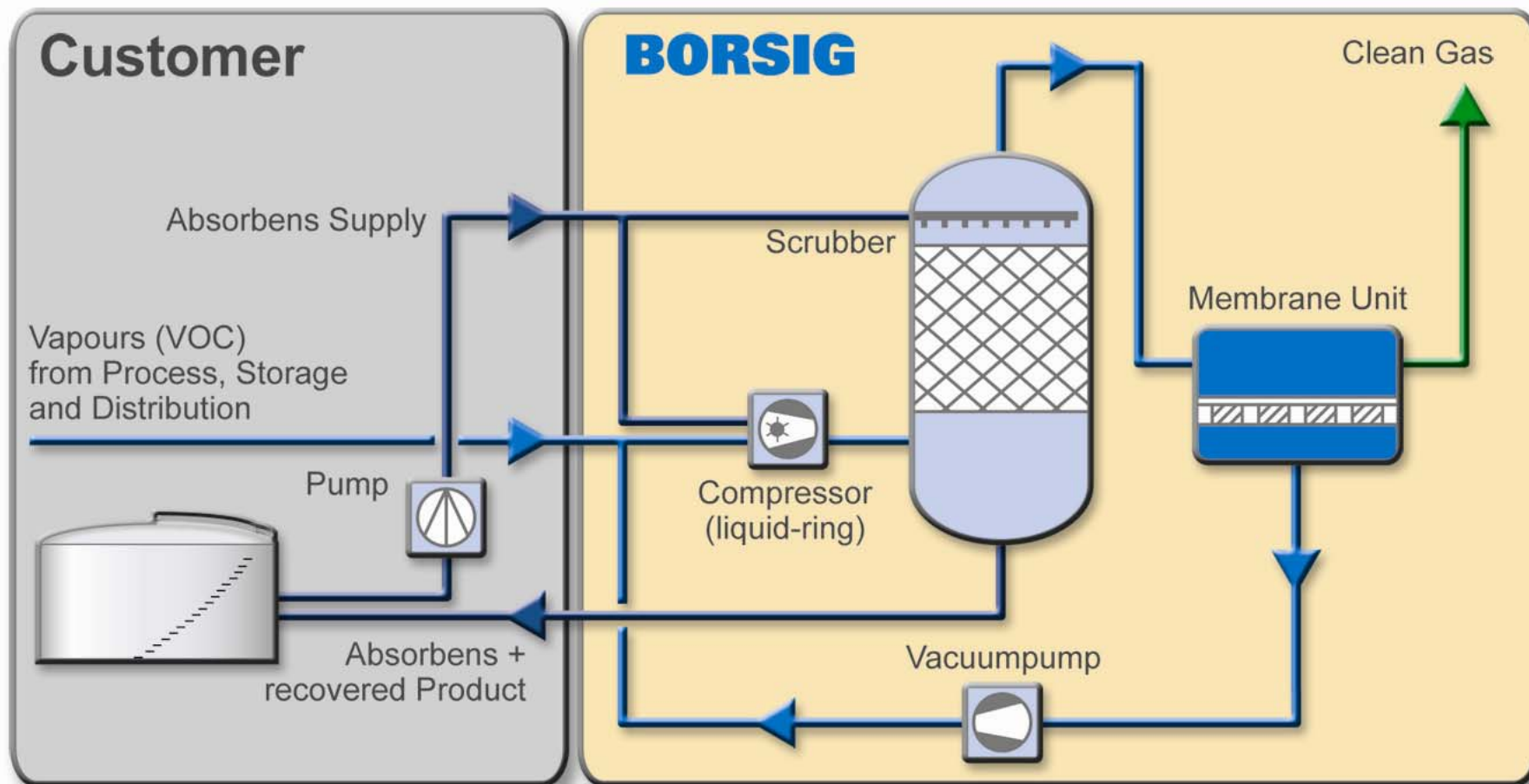


Hydrocarbon Vapour Recovery Process “Condensation / Membrane” – Pure Liquefied Product



Applications - Process “Absorption / Membrane Separation”

Recovery Process with Membrane Separation Unit



Hydrocarbon Vapour Recovery Process “Absorption / Membrane” – Product mixed with Absorbent



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