

Advances in Membrane Materials Provide New Gas Processing Solutions

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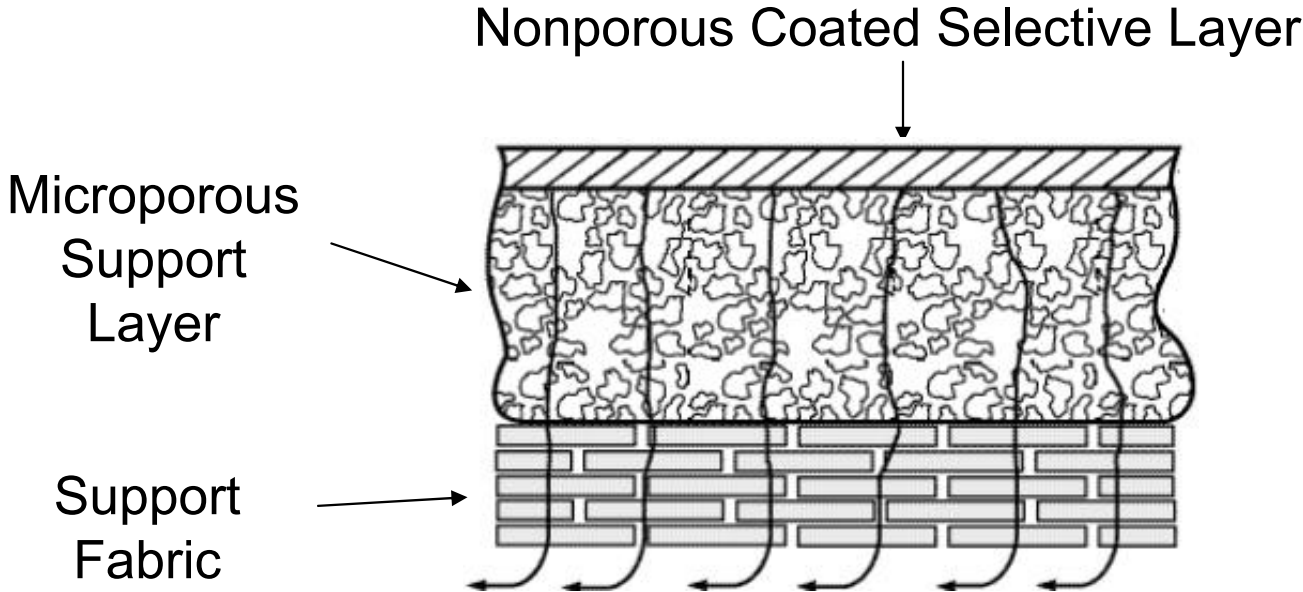
Outline

- ABB–Randall Gas Technologies/MTR Alliance
- Composite Membranes
 - Materials selection flexibility
 - Improved stability and fouling resistance
- New Processes
 - NGL Removal
 - Nitrogen Removal
 - CO₂ Removal
 - H₂S Removal

ABB–Randall Gas Technologies and MTR Have Formed an Alliance

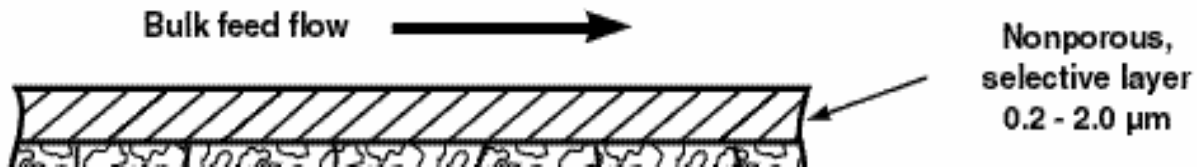
- Randall Gas Technologies
 - A division of ABB Lummus Global (ABB)
 - A process development and engineering company serving the natural gas industry
- Membrane Technology and Research, Inc. (MTR)
 - A supplier of membrane gas separation systems
 - A leader in membrane development

ABB/MTR's Technology is Based on New Composite Membranes



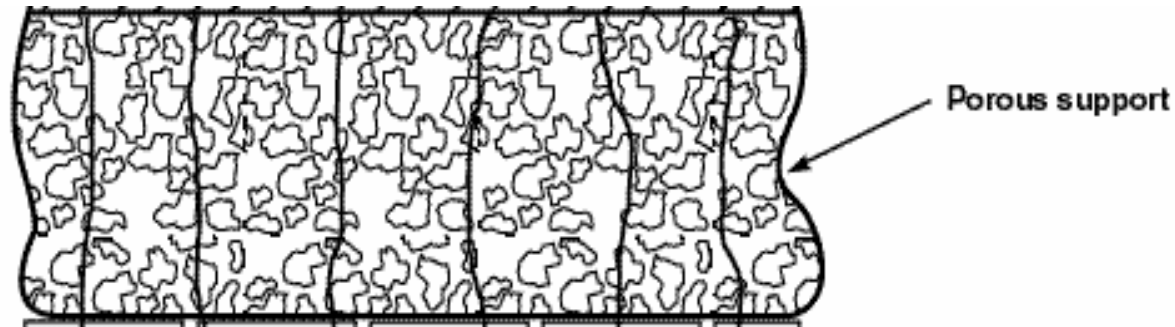
Composite Membrane

The Porous Support and the Selective Layer Can Be Optimized Separately



Desired Properties

- High permeability
- High selectivity
- Chemical resistance



Desired Properties

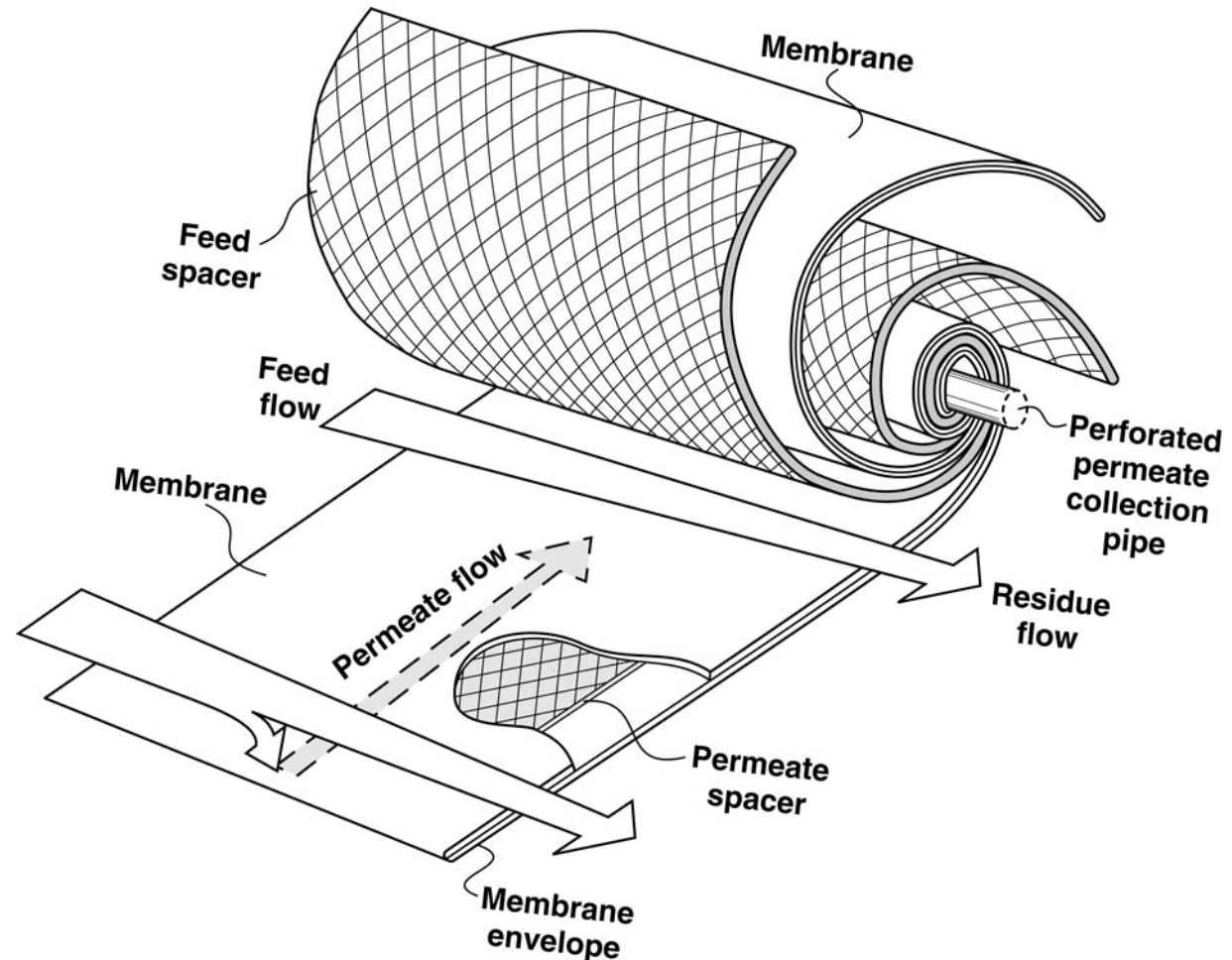
- No mass transfer resistance
- Mechanical strength
- Chemical resistance

Composite Membranes and Processes

<u>Process Name</u>	<u>Separation</u>	<u>Application</u>
VaporSep [®]	NGL/Natural Gas	Fuel Conditioning Dew Point Adjustment
P-Top [™]	H ₂ S/CH ₄	H ₂ S Removal
Z-Top [™]	CO ₂ /CH ₄	CO ₂ Removal
NitroSep [™]	N ₂ /CH ₄	Nitrogen Rejection

Membranes Are Packaged in Spiral-Wound Modules

Each module contains
20 to 50 m² of membrane
Area



Membrane Fouling is a Major Process Design Concern

Potential Foulants in Natural Gas

- Carbon Dioxide
- Hydrogen Sulfide
- Mercury
- Salt
- Asphaltenes
- Waxes
- Water
- Mercaptans
- Oxygen
- Aromatics
- Glycols
- Methanol
- Amines
- Sulfur

Effect of Water and BTEX Aromatics on ABB/MTR's Composite Membranes

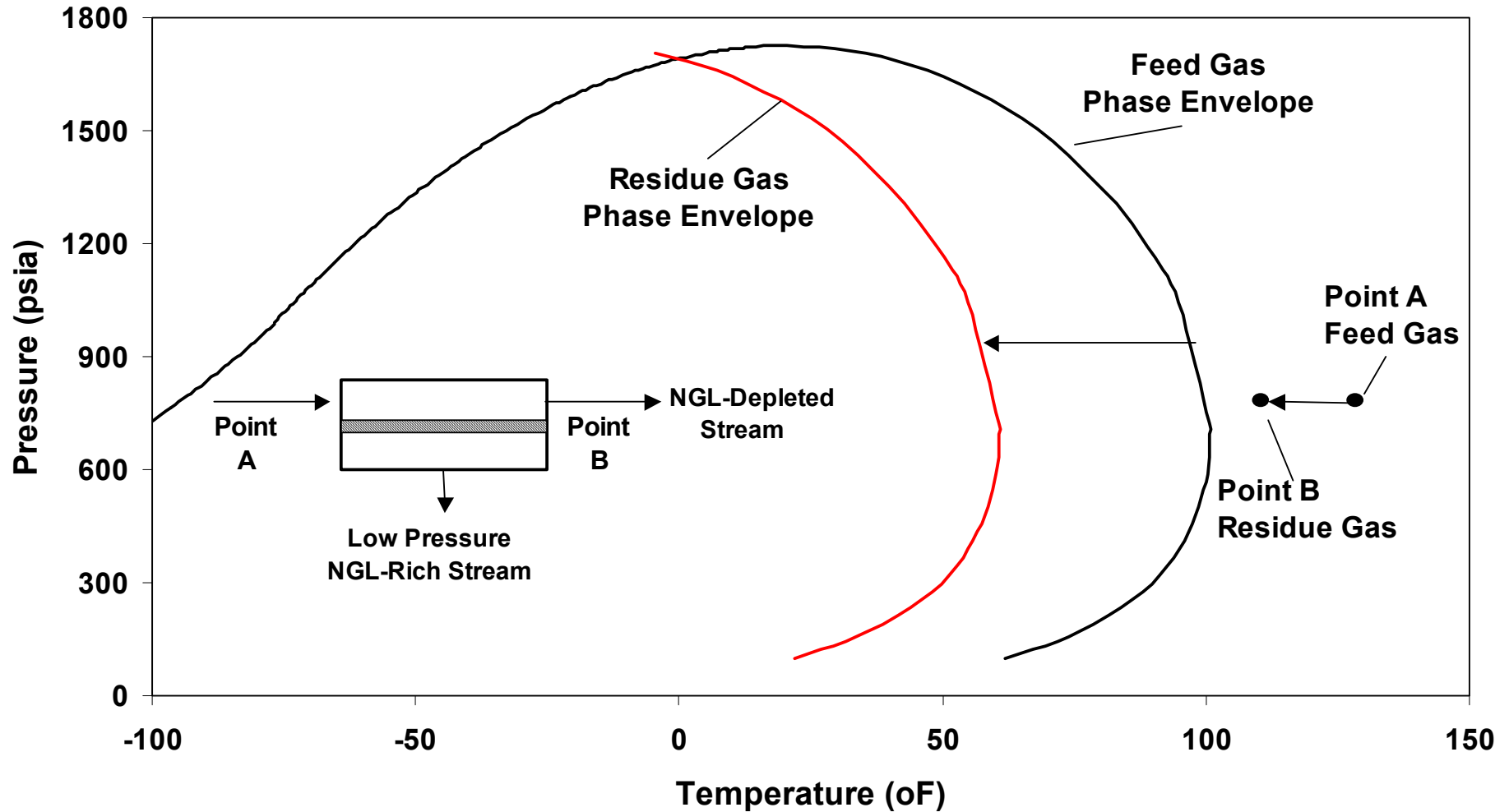
Water

- Membranes are inert to water vapor or liquid
- Water goes with the permeate gas

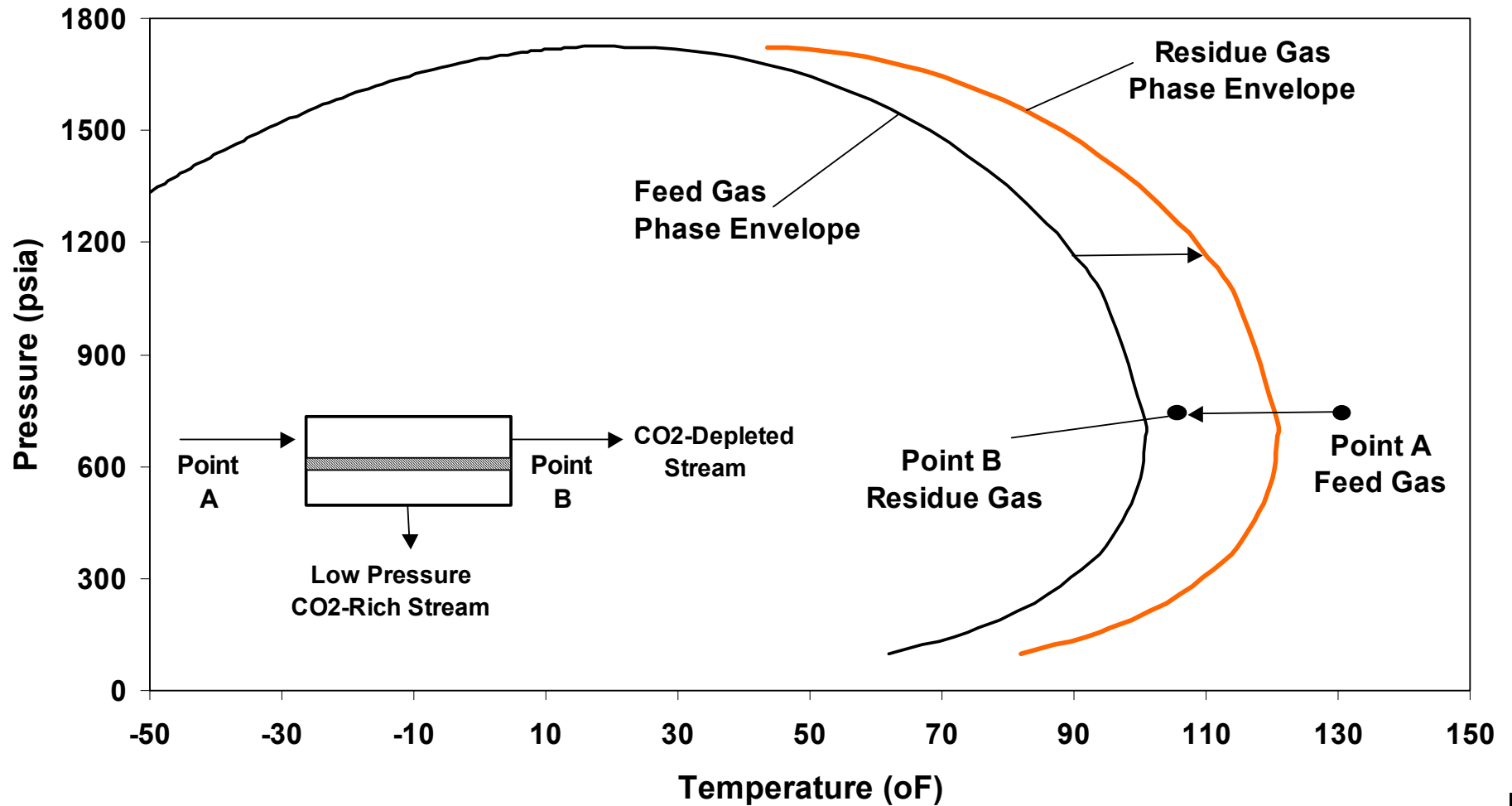
BTEX Aromatics

- VaporSep and P-Top membranes preferentially permeate BTEX
- Vapor concentrations up to saturation are not a problem
- Z-Top rejects BTEX aromatics
- High vapor concentrations do not effect membrane but condensation should be minimized to avoid physical damage

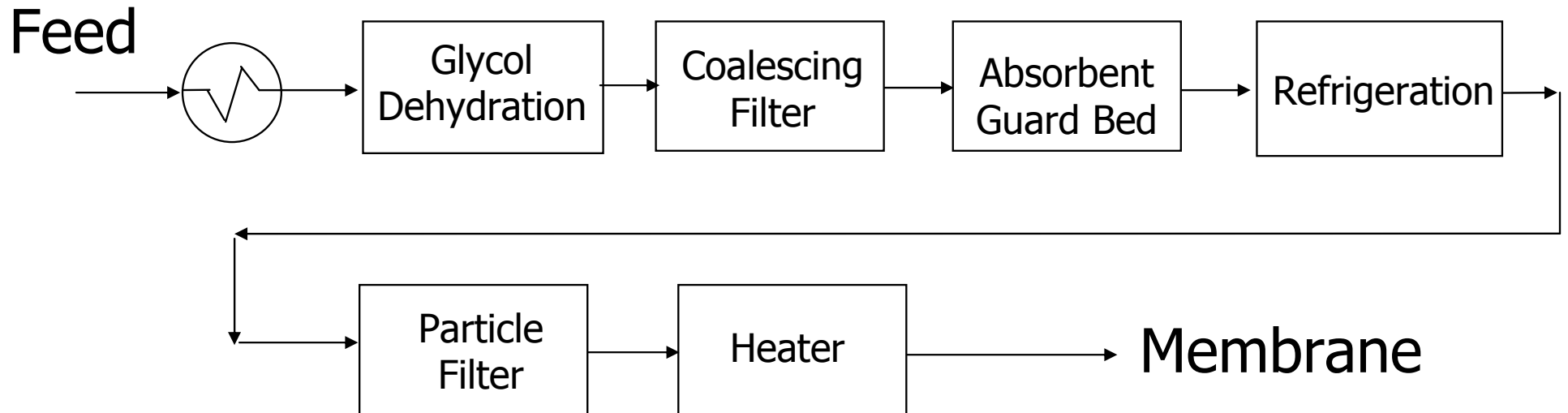
Hydrocarbon-Permeable Membranes Phase Envelope



Hydrocarbon-Rejecting CO2 Permeable Membranes - Phase Envelope



Potential Pretreatment Options for Membrane Systems



- Braces and a belt will handle any upset but are expensive
- Tough membranes minimize pretreatment required

ABB/MTR Processes

- NGL Removal by VaporSep™
- Nitrogen Removal by NitroSep™
- CO₂ Removal by Z-Top™
- H₂S Removal by P-Top™

History of NGL Membrane Applications

- A long history of use for various hydrocarbon separation and recovery applications
- Commercial success – Prestigious Kirkpatrick Award
Winning Technology
 - ♦ Applied for wide range of flows: 0.2 to 90 MMscfd
 - ♦ Applied at wide range of pressures: 50 to 1,000 psia
- More than 80 reference plants worldwide
- Customers include ExxonMobil (8 Plants), BP Amoco (4 Plants), Sabc (4 plants), Formosa (10 plants)
- More than 400 years of cumulative on-stream time

Propylene and Isobutane Recovery Membrane Unit at a Polyolefins Plant



NGL Separation - Applications

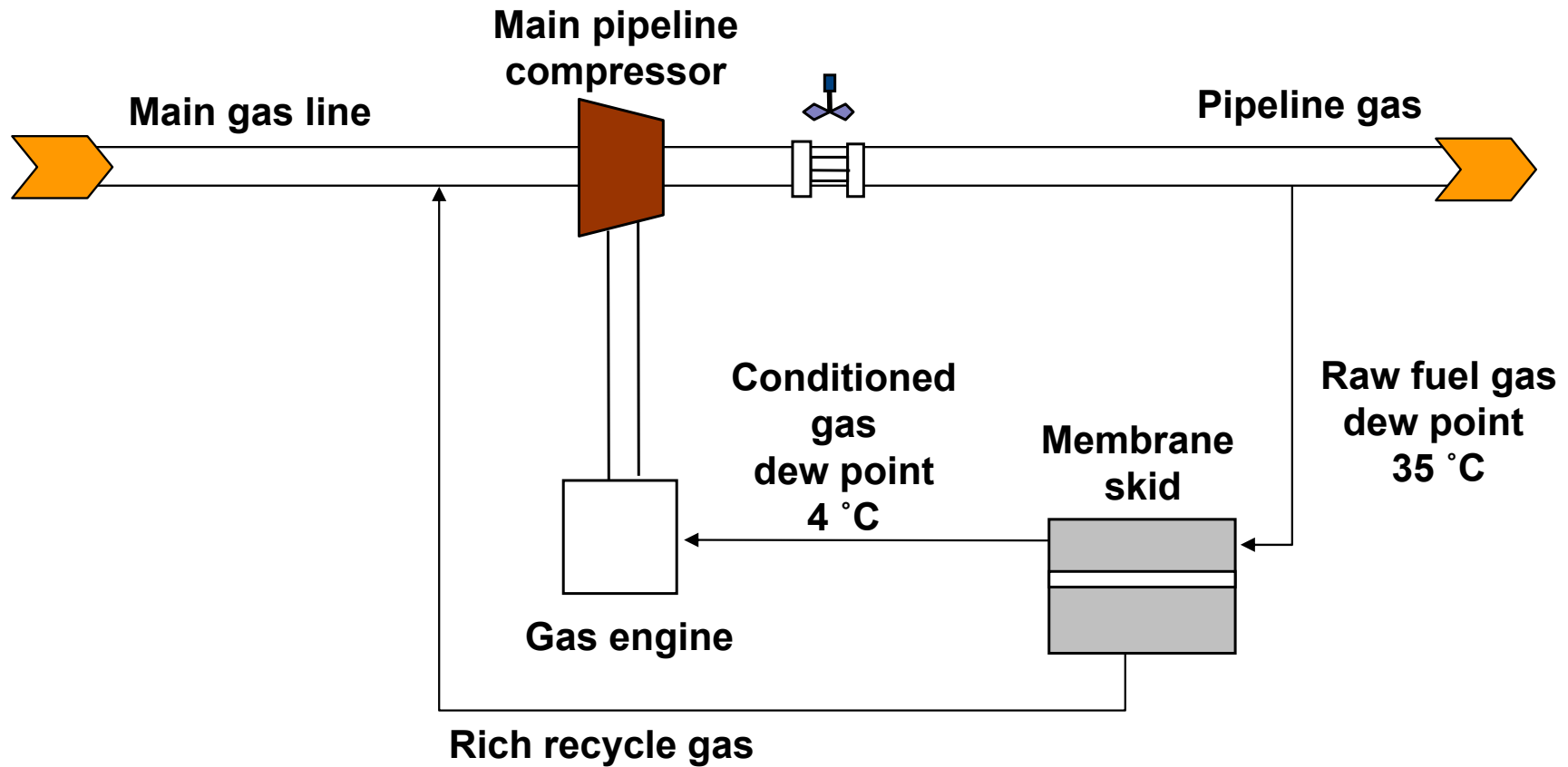
- Dew point control
- Conditioning of rich fuel gas
 - Three reference plants
 - Good fix for “black start gas” problem

NGL Separation – UEG (El Paso) System



- Operational since May, 2002
- Processing 90 MMSCFD @ 900 psig
- Constant performance reducing C_{3+} to meet Siemens Turbine Fuel Specs.
- System Turndown to 25%
- System delivery in 14 weeks.

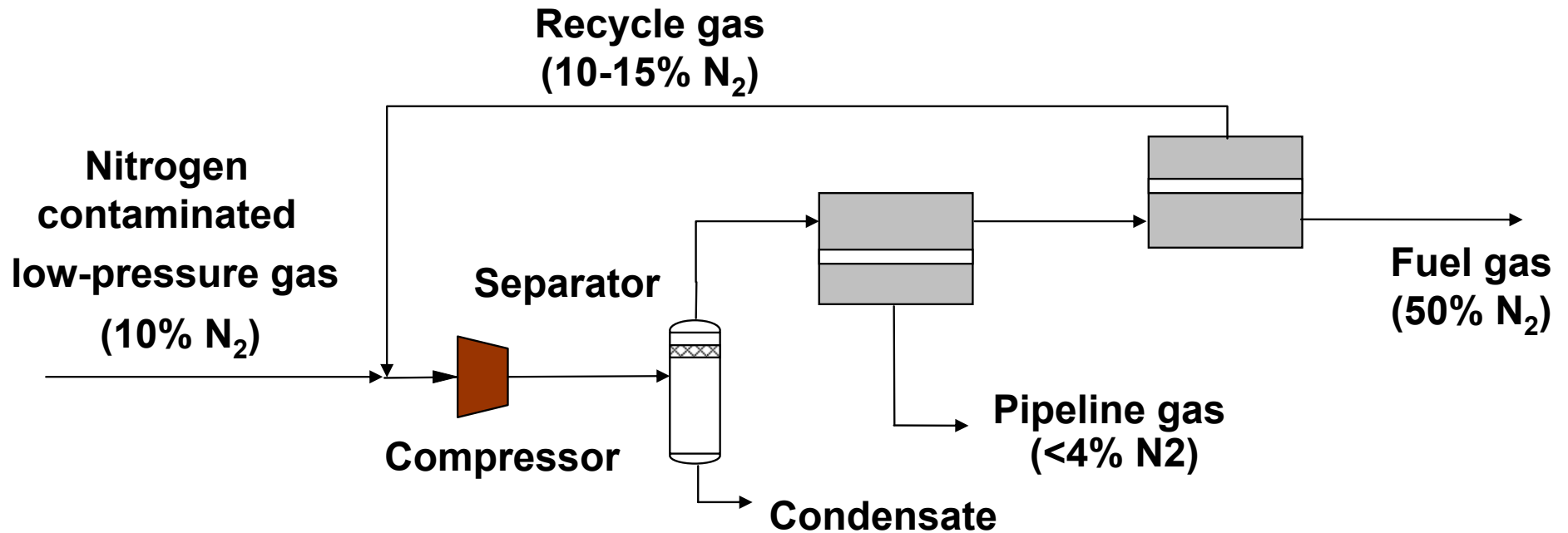
Fuel Gas Conditioning Process Design



Comparison of Nitrogen Removal Processes

Process	Flow Range (MMscfd)	Complexity	Hydrocarbon Recovery	Development Stage
Cryogenic	>15	Complex	heavy hydrocarbons In product gas	Mature
PSA	2-15	Simple; batch operation requires bed switching	heavy hydrocarbons in tail gas	Early commercialization
Membrane	0.5-25	Simple continuous operation	heavy hydrocarbons in product gas	Early commercialization

Nitrogen Removal Process



Nitrogen Removal Skid



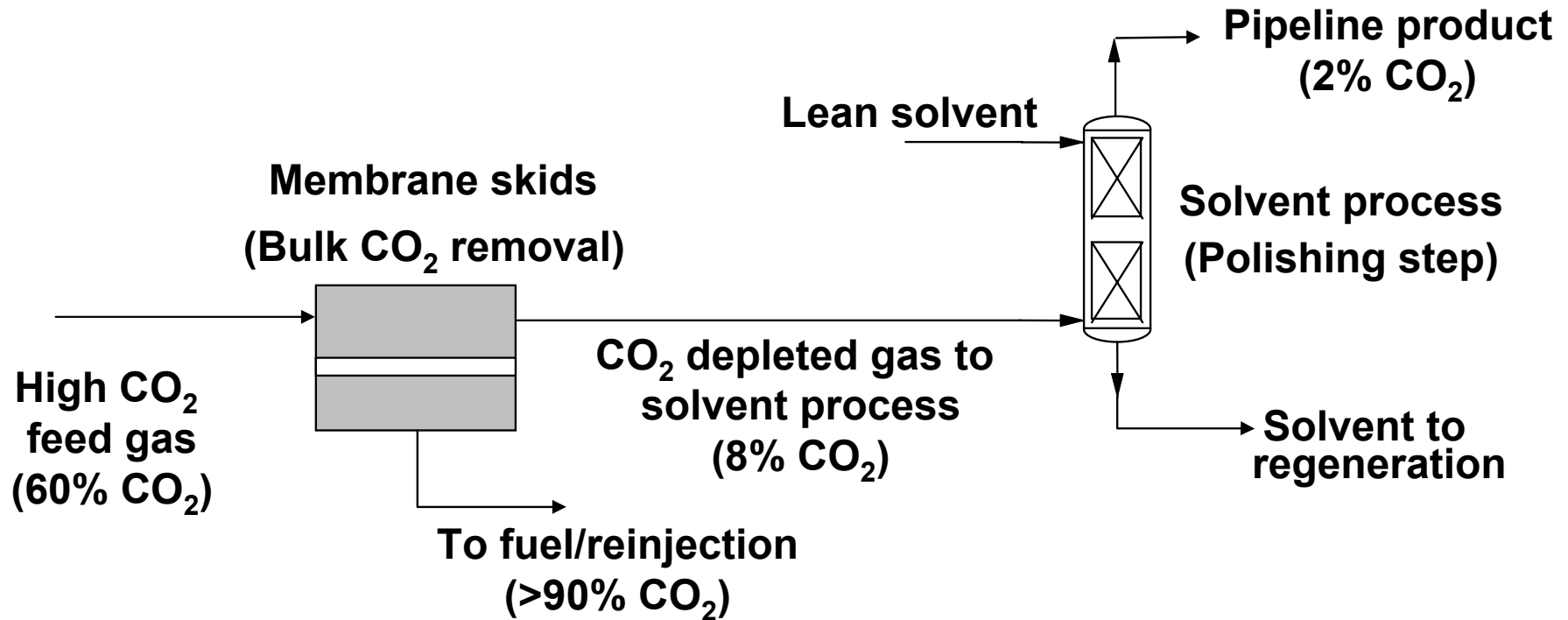
- Operational since November , 2002
- Constant performance reducing N₂ content in natural gas from 6.5 mol-% to 2.5 mol-%.
- System Turndown to 50% on the fly

Nitrogen Removal Process – Green Ranch

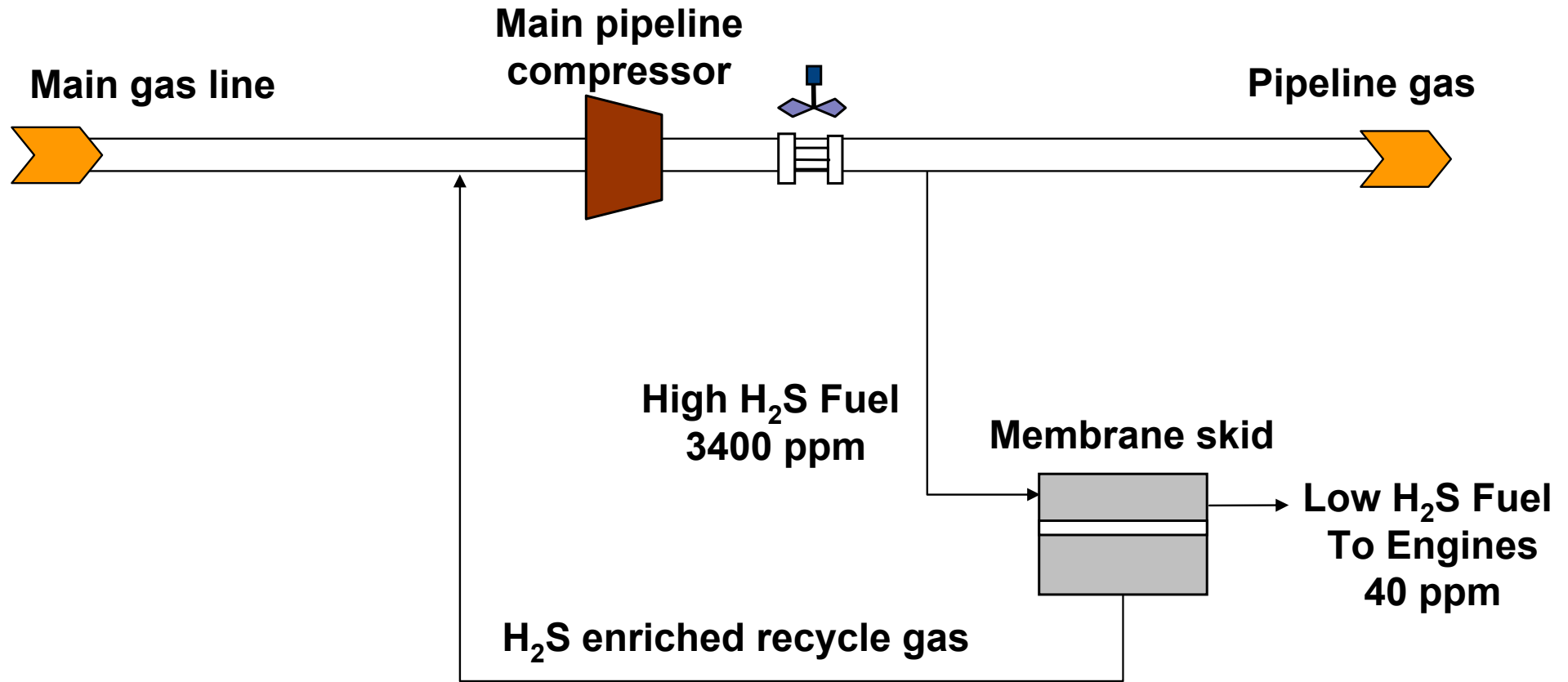


- Under Installation at Site
- Reducing N₂ content in natural gas from 24 mol-% to 4 mol-%.
- Unattended operation – Remote Monitoring
- Capacity: 1 MMSCFD
- Designed for maximum flexibility for variation in inlet pressure, product pressure and flow rate.

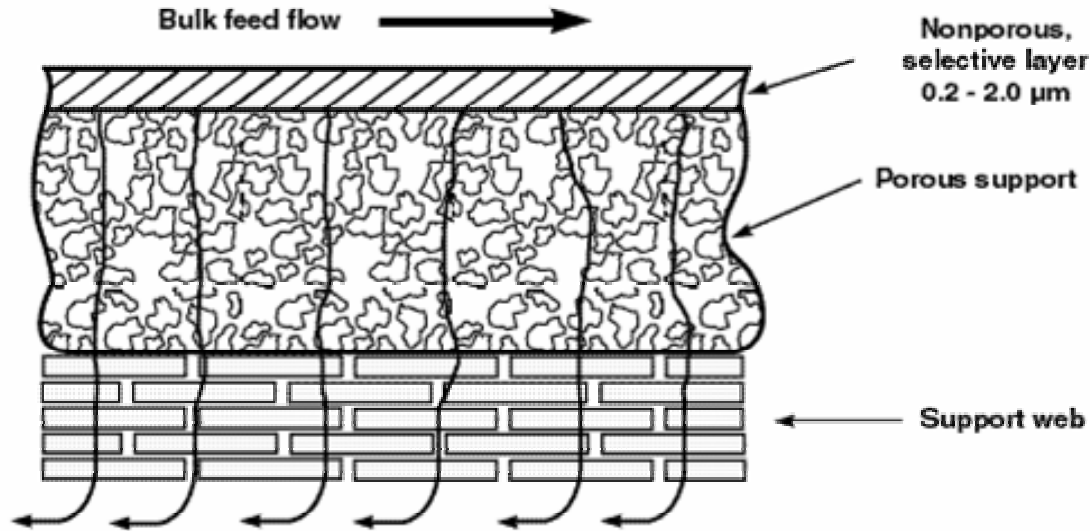
CO₂ Removal: High CO₂ Feed Gas



H₂S Removal – Fuel Gas Treatment



Composite Membranes: A Breakthrough in Membrane Technology



- Reduced pretreatment
- Greater flexibility in material selection
- Better performance
- Many new applications

Membranes Are Not Just for CO₂ Anymore

H₂S

Heavy Hydrocarbons

Nitrogen

All Are Possible

Thank You!

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and

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