

New Membrane Applications in Gas Processing

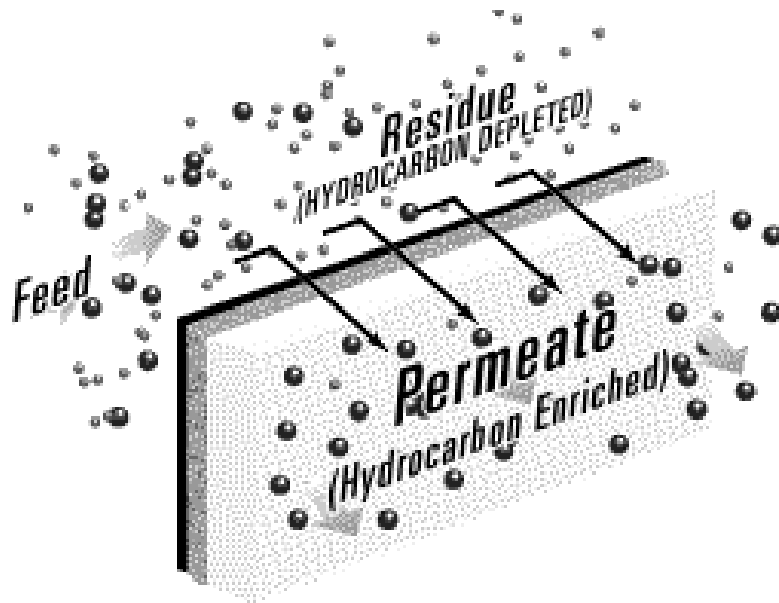
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Membrane Separation Mechanism



$$\text{Permeability (P)} = \text{Diffusivity (D)} * \text{Solubility (S)}$$

Membrane Selectivity

$$\frac{P_1}{P_2} = \frac{D_1 \cdot S_1}{D_2 \cdot S_2}$$

**MTR's Rubbery Membranes Reject Methane
and preferentially permeate the heavy hydrocarbons**

Glassy v/s Rubbery Membranes

Glassy Membranes

Fast Gas

Hydrogen

H₂O

CO₂

Nitrogen

Methane

Ethane

Propane

Slow Gas

Hexane

Rubbery Membranes

Fast Gas

Hexane

H₂O

Propane

Ethane

CO₂

Methane

Hydrogen

Slow Gas

Nitrogen

Membrane System Installations

Gas/Gas Separation Systems

$H_2/N_2, CH_4$	~ 200 Units
O_2/N_2	~ 5,000 Units
CO_2/CH_4	~ 200 Units

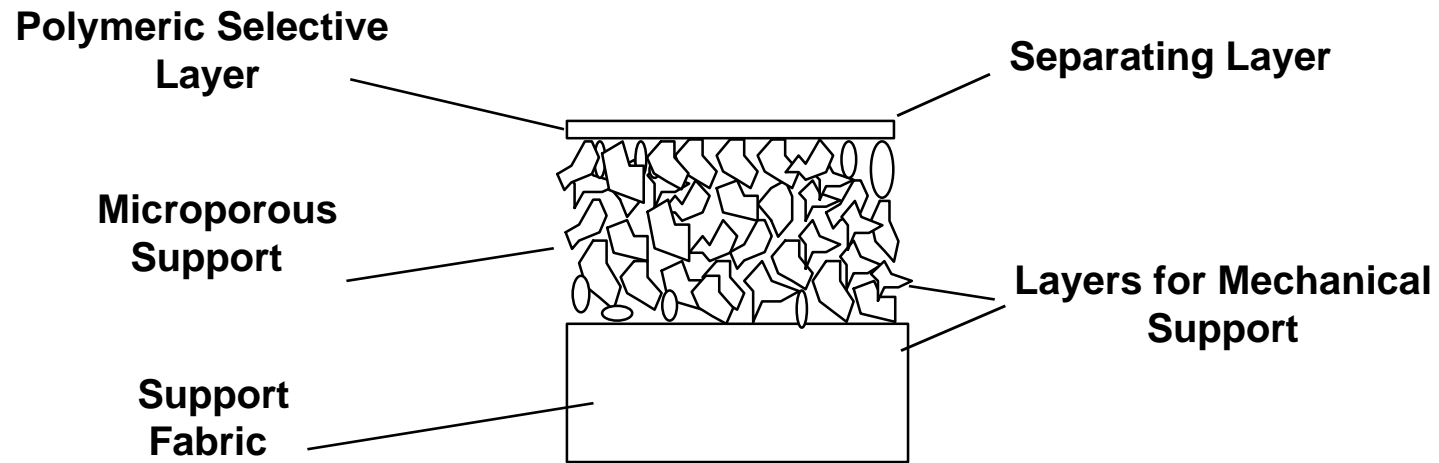
**Glassy
Membranes**

Vapor/Gas Separation Systems

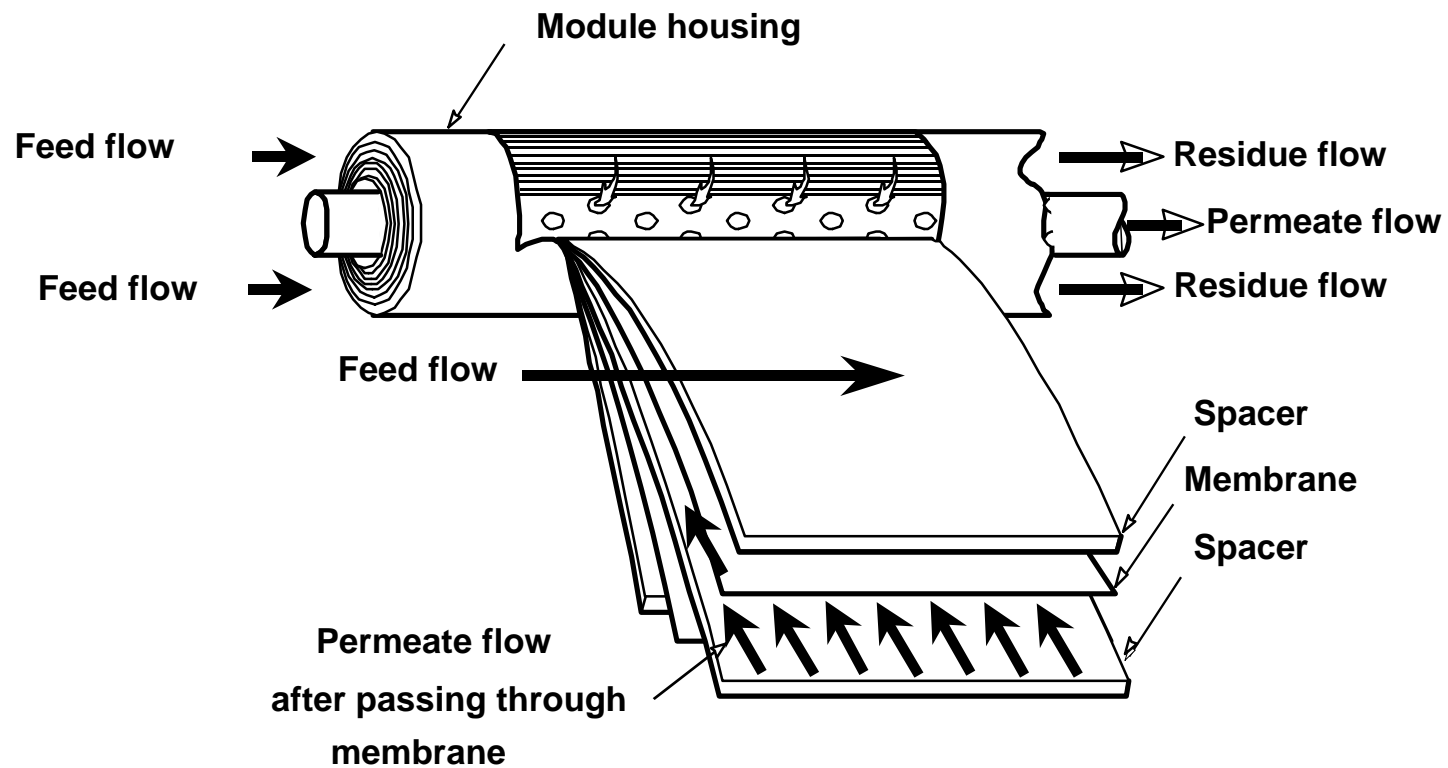
VOC/Air	
Hydrocarbon/ N_2, CH_4	~ 100 Units

**Rubbery
Membranes**

MTR's Composite Membrane



MTR Spiral Wound Cartridge



NGL Separation Skid



Flow Capacity

Max: 8 MMSCFD

Operated: 2.5-3.0 MMSCFD

Pressure rating

Max: 1250 psig

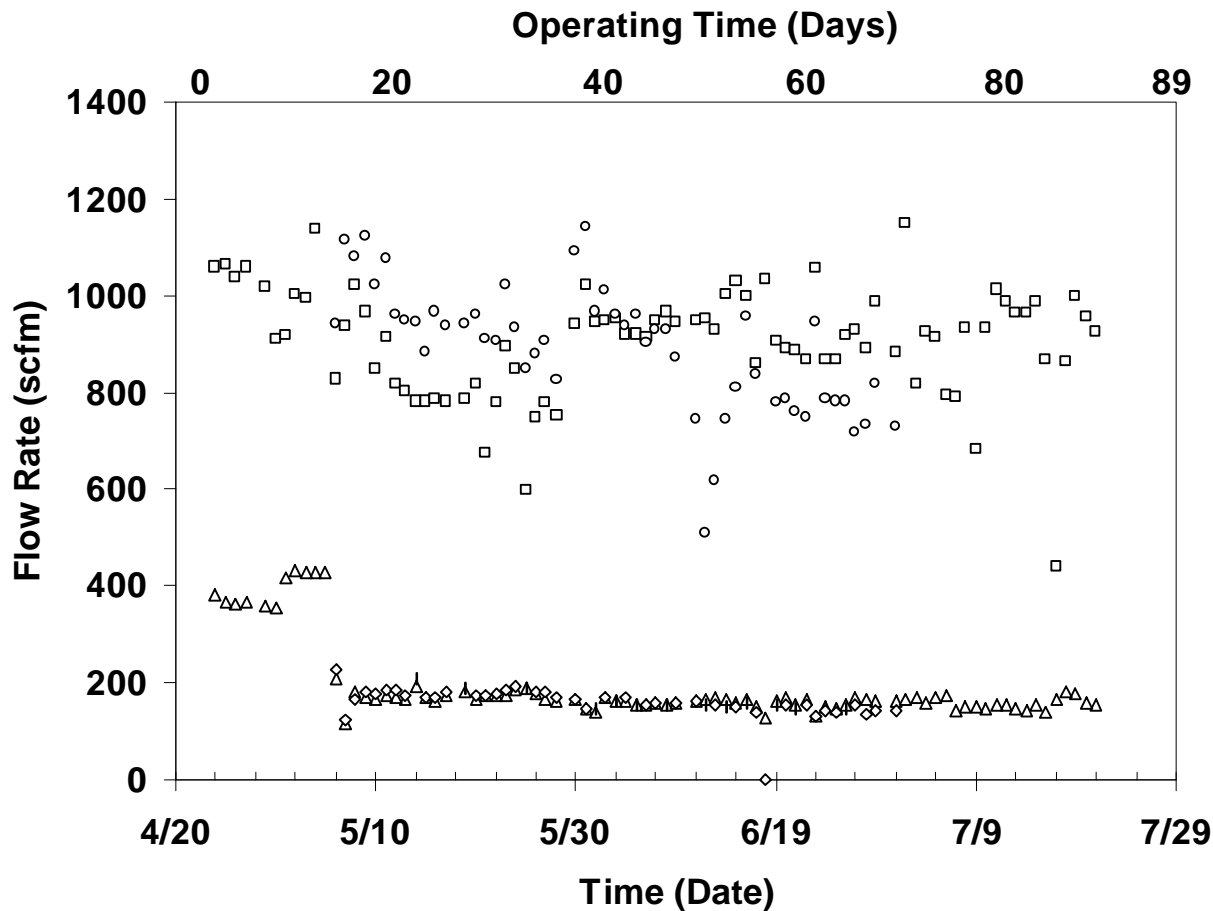
Operated: 475 psig

Temperature

Max: 135°F

Operated: 100-125°F

Field Data - Feed/Permeate Flow rates



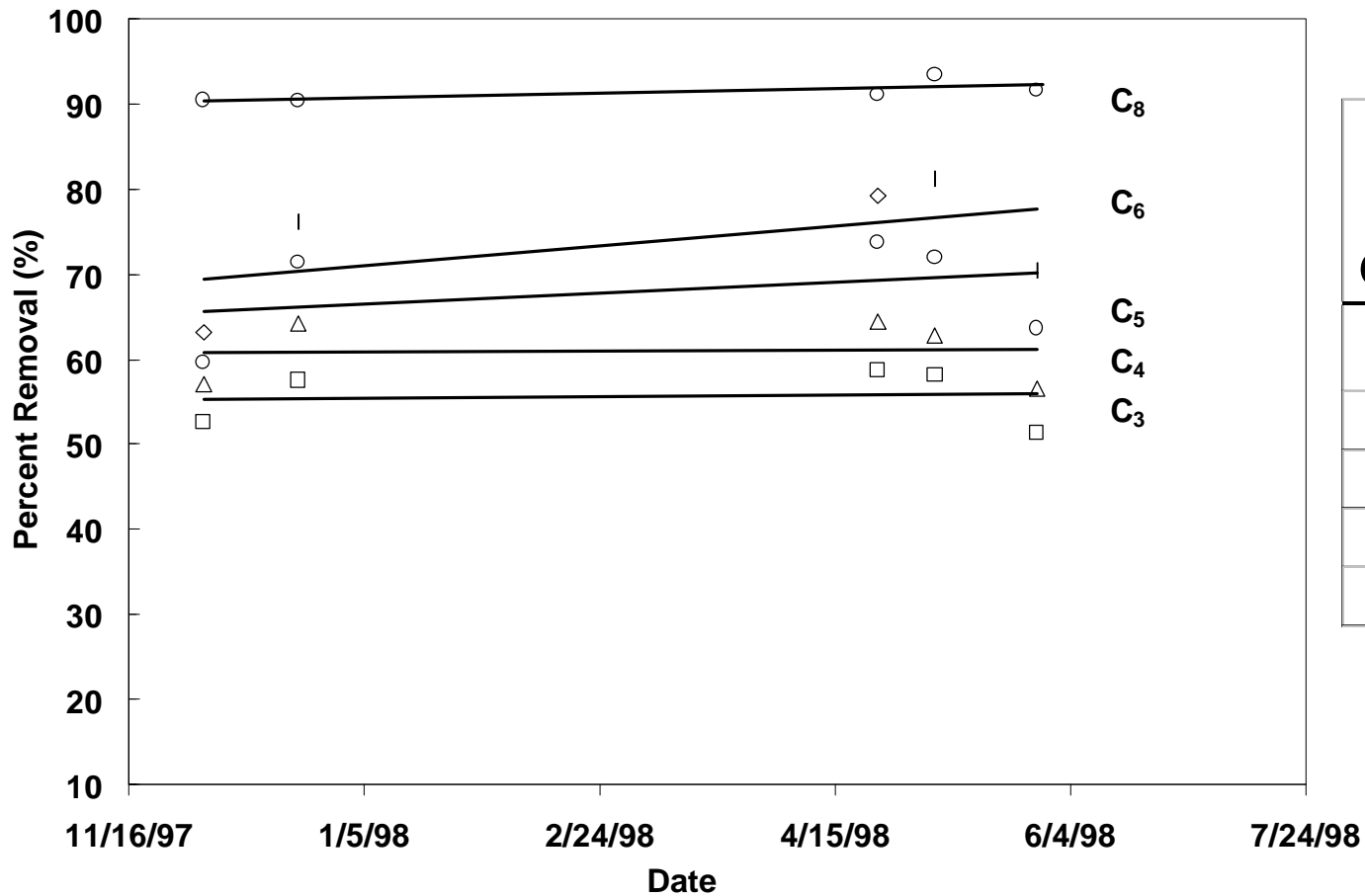
Location: Chevron's Lost Hills Station, CA

Feed pressure: 450 psig

Avg. Feed Flow rate: 2.8 MMSCFD
Avg. Permeate Flow rate: 0.6 MMSCFD

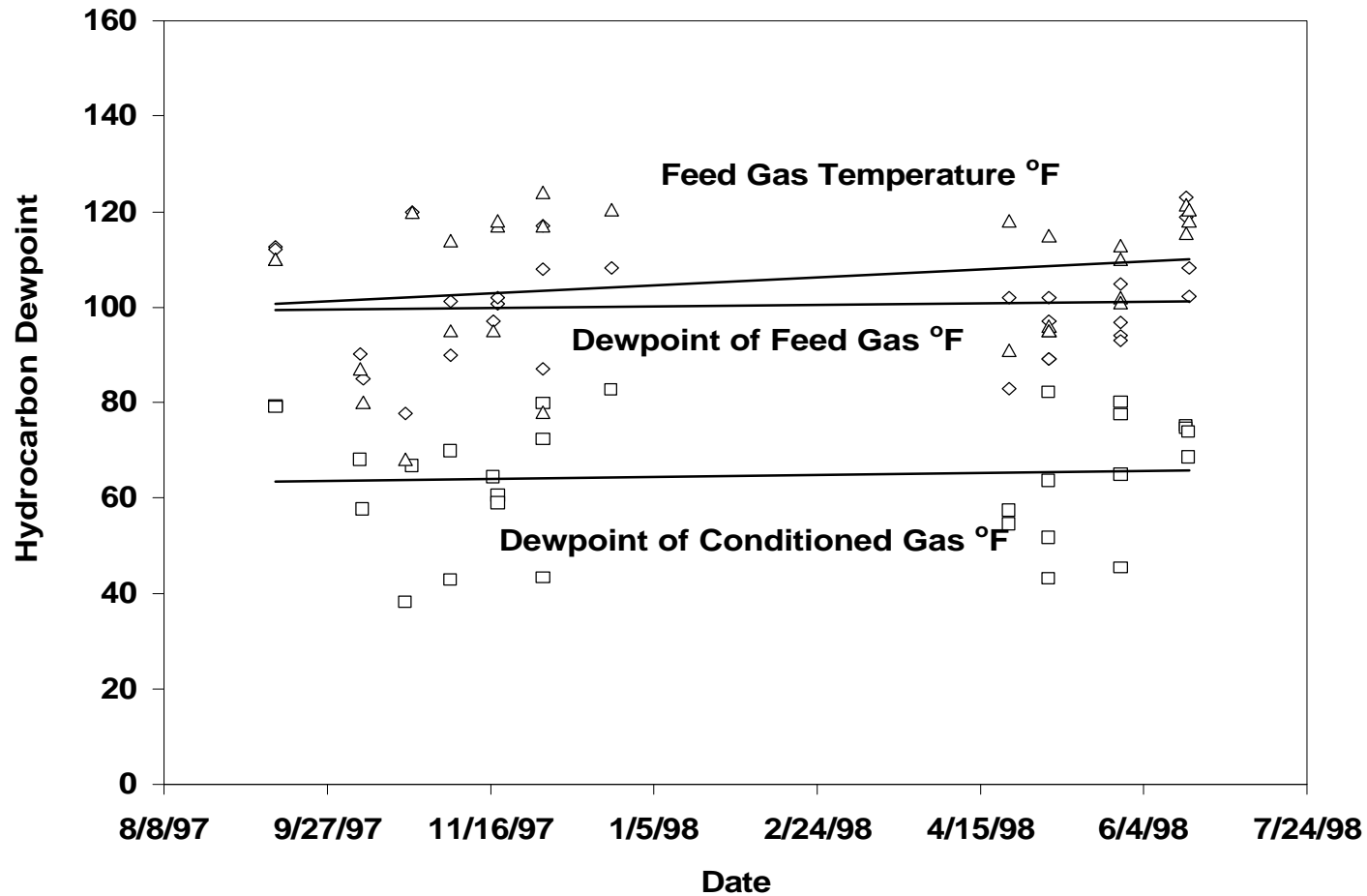


Field data - Percent Removal Rates



Component	Average % Removal
Propanes	55.7
Butanes	61.0
Pentanes	68.1
Hexanes	74.0
Octanes	91.4

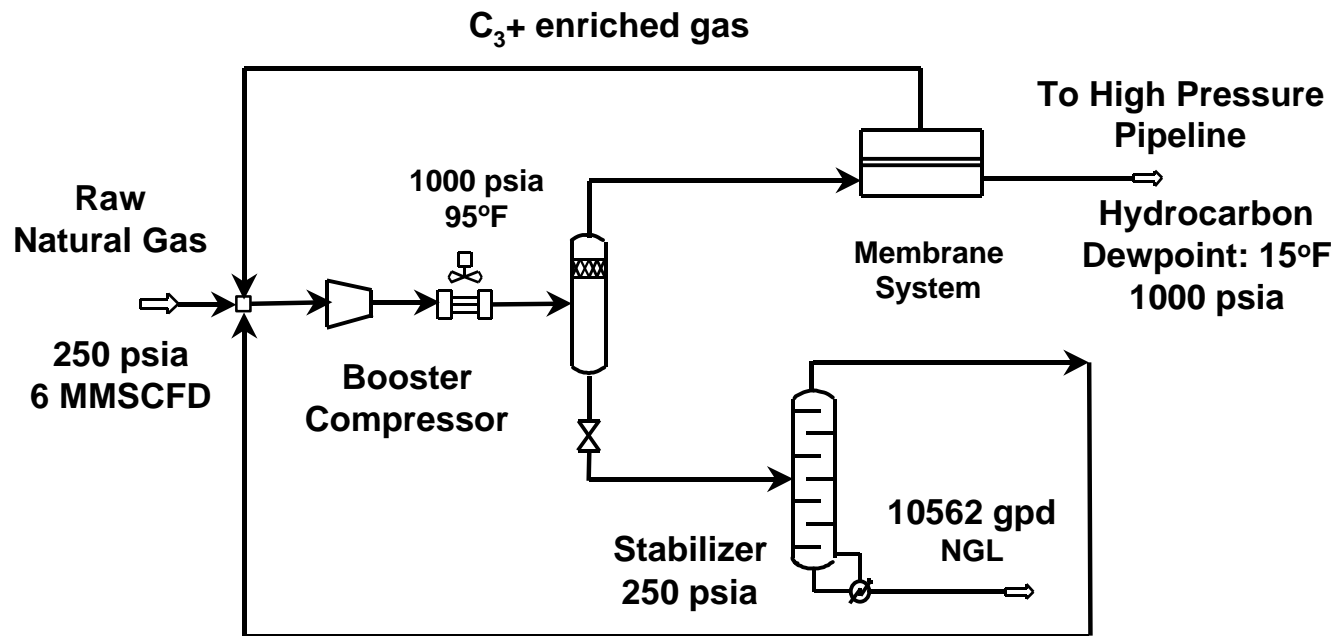
Field Data - Hydrocarbon Dewpoints



NGL Separation and Recovery Applications

- **Well-head Gas Dewpoint Control**
- **Associated Gas Liquids Recovery**
- **Engine and Turbine Fuel Gas Conditioning**
- **Propane Refrigeration Plant Debottleneck**
- **Re-injection Gas Liquids Recovery**
- **Flare Gas Liquids Recovery/Conditioning**
- **Vapor Recovery from Storage Tank Losses**

Wellhead Dewpoint Control



Value of NGL (@ \$ 14/bbl): \$ 1.2 Million/yr

Both Hydrocarbon and Water Dewpoint Reduced in one process

Price of VaporSep System: \$ 750,000-850,000

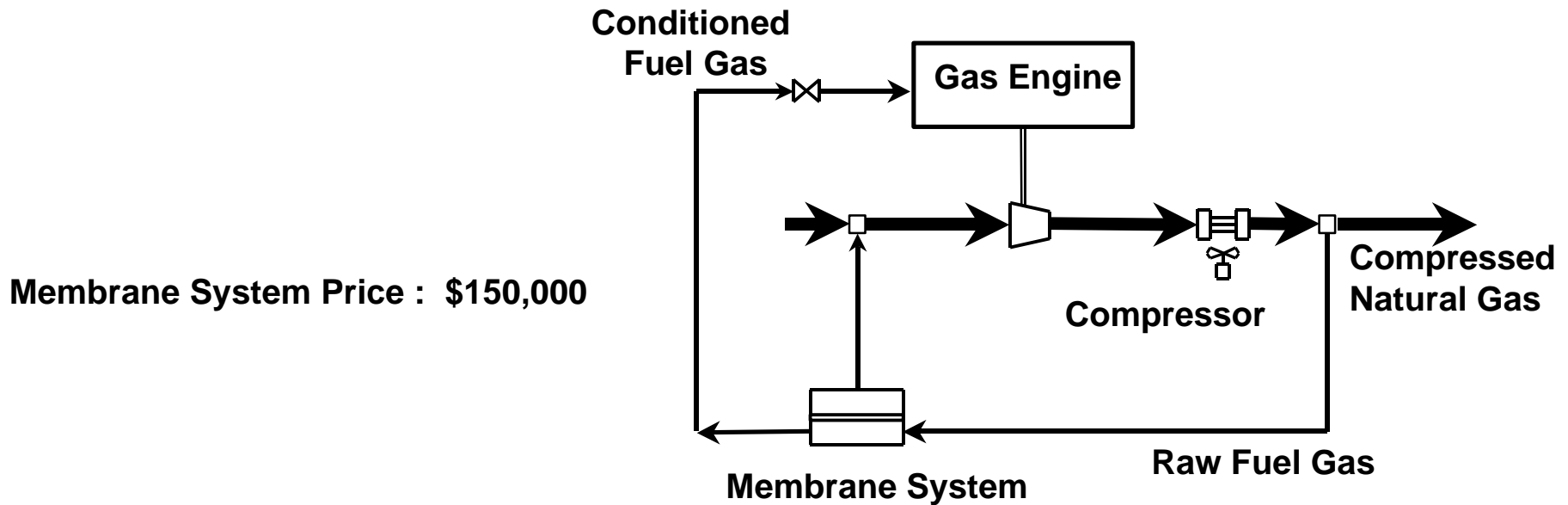
Economic Comparison – Dewpoint Control

Process	Installed Cost (MM\$)	Processing Cost (\$/inlet Mscf)
Propane Refrigeration	1.6	0.165
Membrane	1.1	0.098

Basis: 10 MMSCFD Plant/Lean Gas (3.9 GPM, 1185 Btu/SCF)

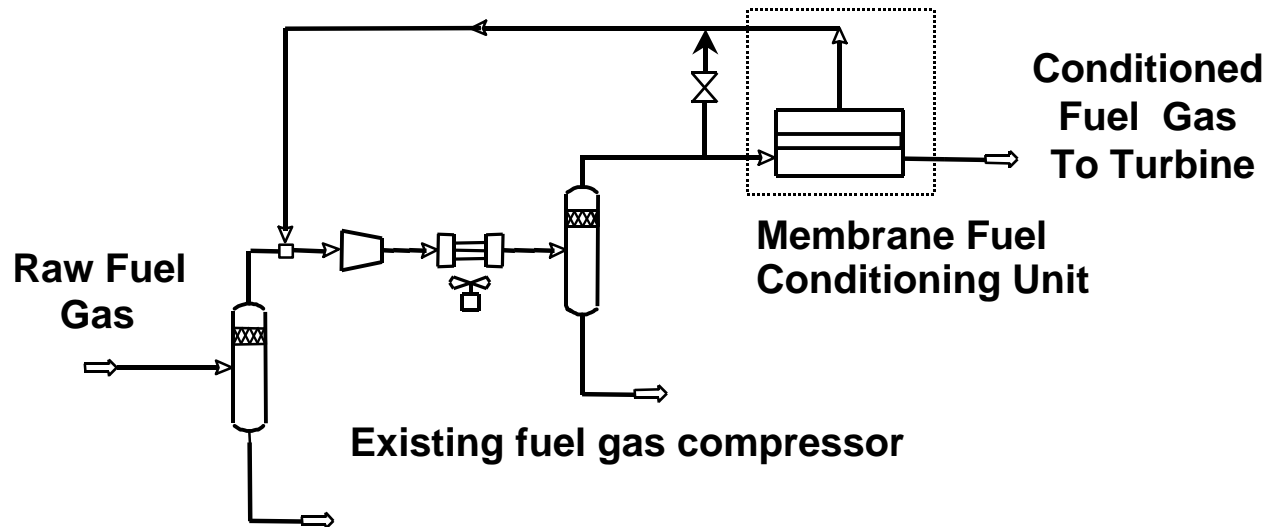
Propane Refrigeration Cost: Purvin and Gertz, June 1999, Private Study

Fuel Gas Conditioning - Gas Engine Example



<u>Process Conditions</u>	<u>Membrane Feed</u>	<u>Conditioned Fuel Gas</u>
Temperature °F	95	51
Pressure (psia)	955	945
Flow Rates (MMscfd)	0.95	0.5
Octane Number	113.7	116
Hydrocarbon Dewpoint (°F)	95	37

Fuel Gas Conditioning - Gas Turbine Case



Fuel Gas Flow Rate (MMSCFD) :	6.1
Feed Temperature (°F) :	120
Conditioned Fuel Dewpoint(°F) :	76
NGL Recovered (gpd) :	15,000
Value of Recovered NGL (US \$) :	500,000
Membrane System Price (US \$) :	400,000 – 600,000

Typical Fuel Conditioning Skid-mounted Unit

Designed for Offshore Installation

Main System Components

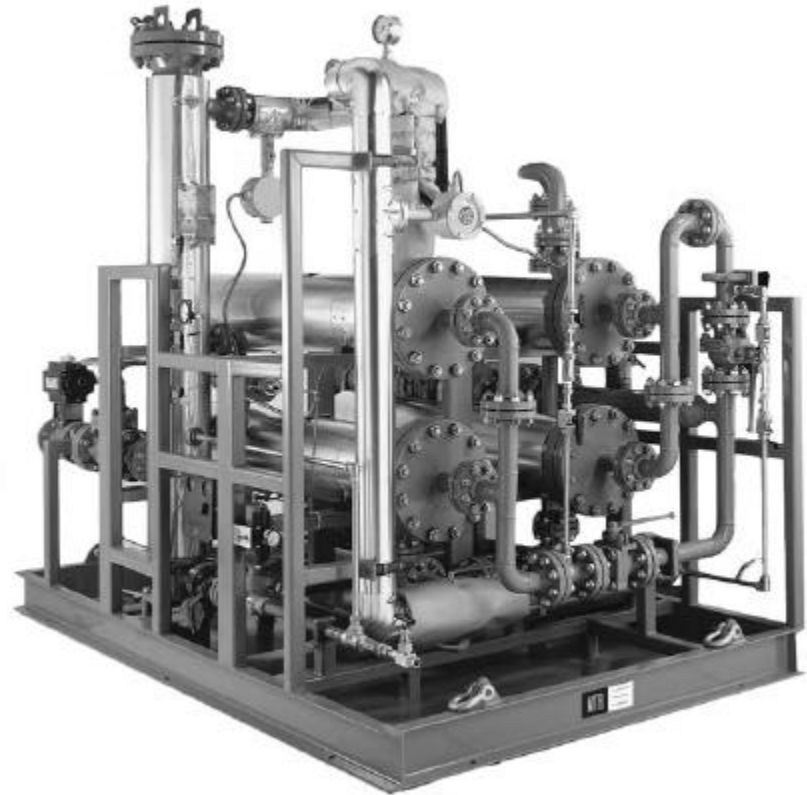
**Membrane Modules/Housings
Filter Separator/Coalescer
Inlet and Discharge Valves**

System Dimensions: 6 ft (W) x 8 ft (L) x 8 ft (H)

Location: Nigeria

**Flow Capacity: 2.5 MMSCFD
Pressure rating 550 psig
Operating pressure: 220 psig**

**Feed hydrocarbon dewpoint: 82°F
Conditioned Gas Dewpoint: 20°F**



Advantages of Membrane Systems

- **Simple passive system**
- **High on-stream factor (typically > 98%)**
- **Minimal or no operator attention**
- **Small footprint, low weight (Platform Applications)**
- **Ambient temperature operation in many applications**
- **Large turndown ratio**
- **Low maintenance**
- **Lower capital and operating costs**

Summary

Wide range of applications in the Oil, Gas and Refining Industries

- Gas:** Fuel gas conditioning, NG dewpointing, Natural Gas Dehydration.
- Oil:** Associated gas processing, Vapor recovery from storage tanks and transportation.
- Refining:** LPG/Fuel gas, Hydrotreater/Hydrocracker Purge, Refinery gas plant, Hydrogen recovery.