New Membrane Applications in Gas Processing

By

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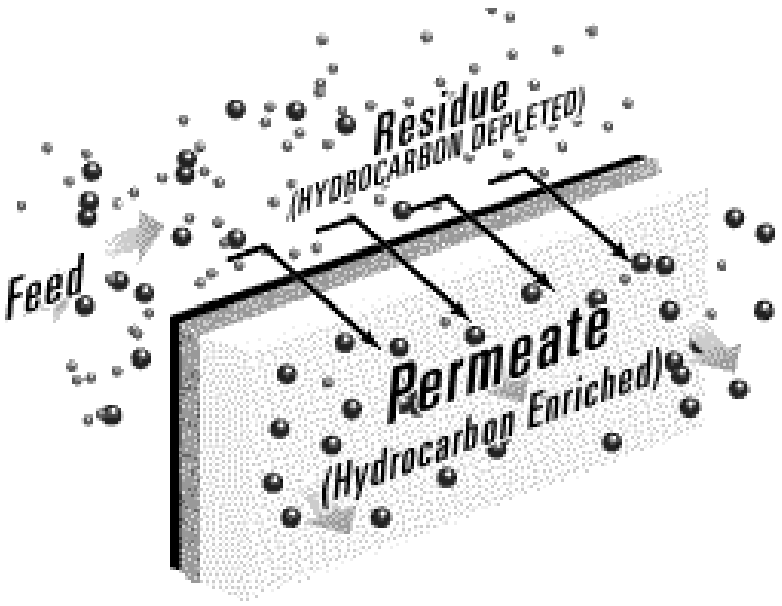
Membrane Separation Mechanism



Permeability = Diffusivity * Solubility
(P) (D) (S)

Membrane Selectivity

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

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

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Glassy v/s Rubbery Membranes

Glassy Membranes

Fast Gas **Slow Gas**

Hydrogen	Nitrogen	Ethane	Hexane
H_2O	CO_2	Methane	Propane

Rubbery Membranes

Fast Gas **Slow Gas**

Hexane	Ethane	Methane	Nitrogen
H_2O	Propane	CO_2	Hydrogen

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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

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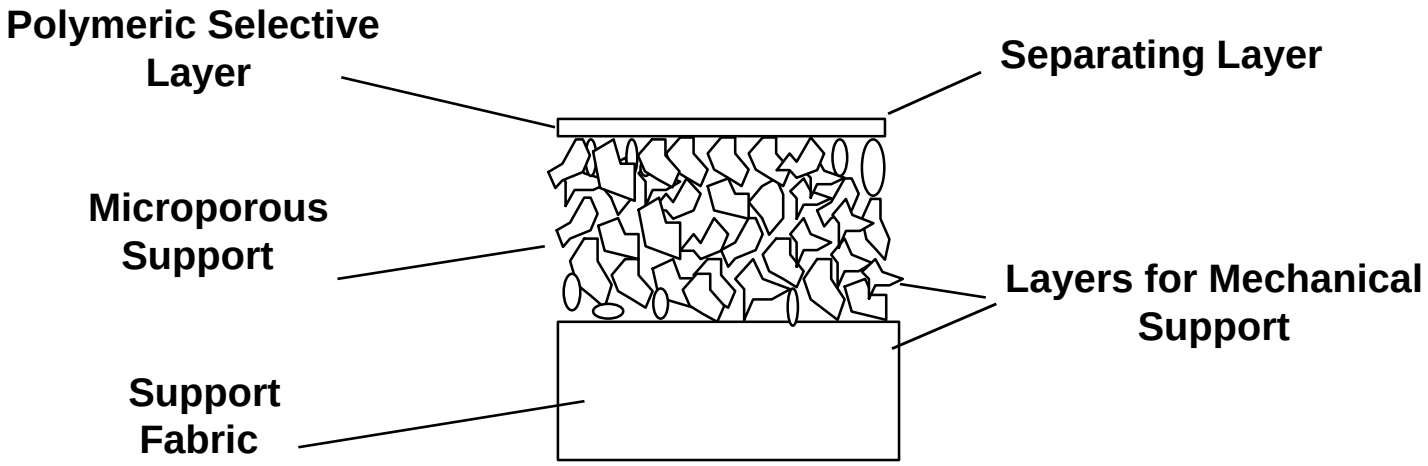
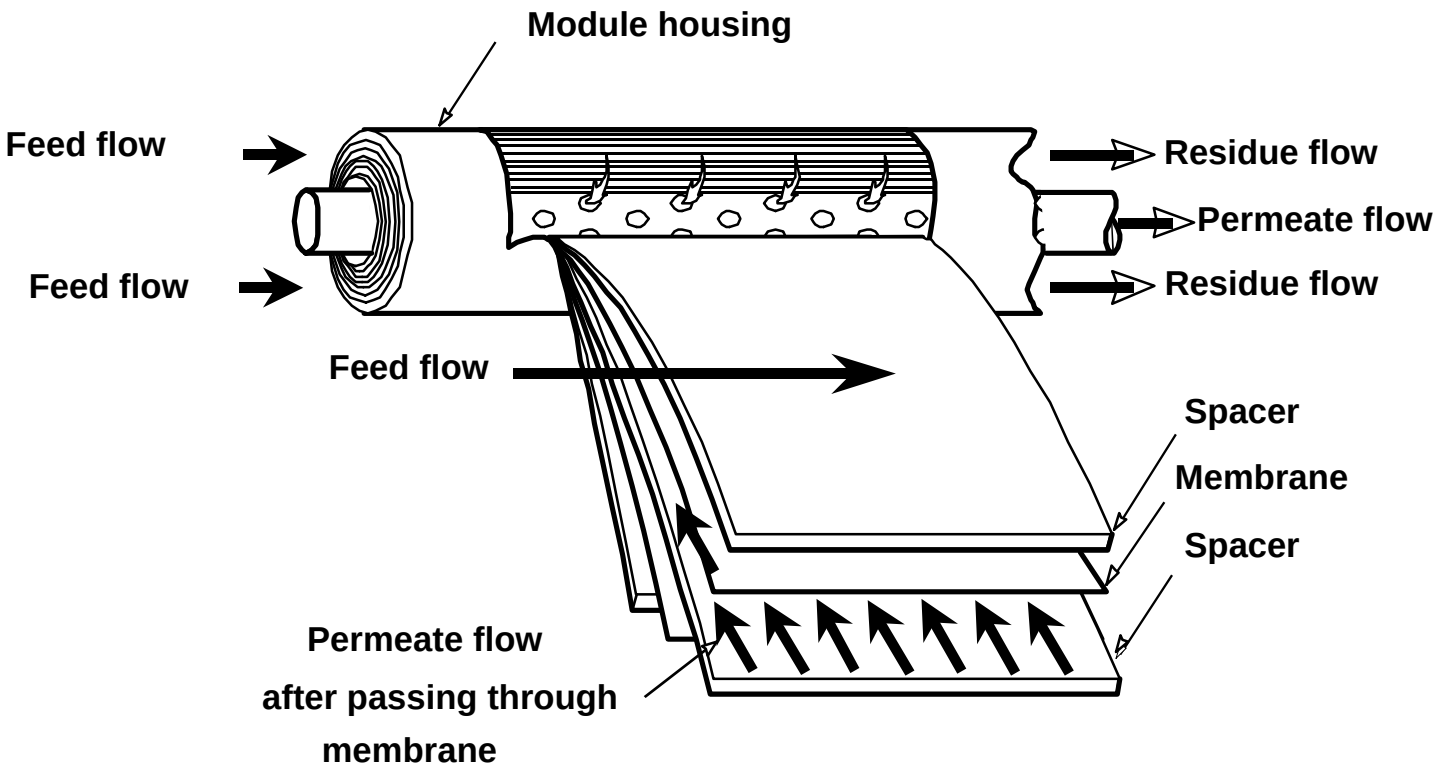
MTR's Composite Membrane



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^{o}F
Operated: 100-125^{o}F

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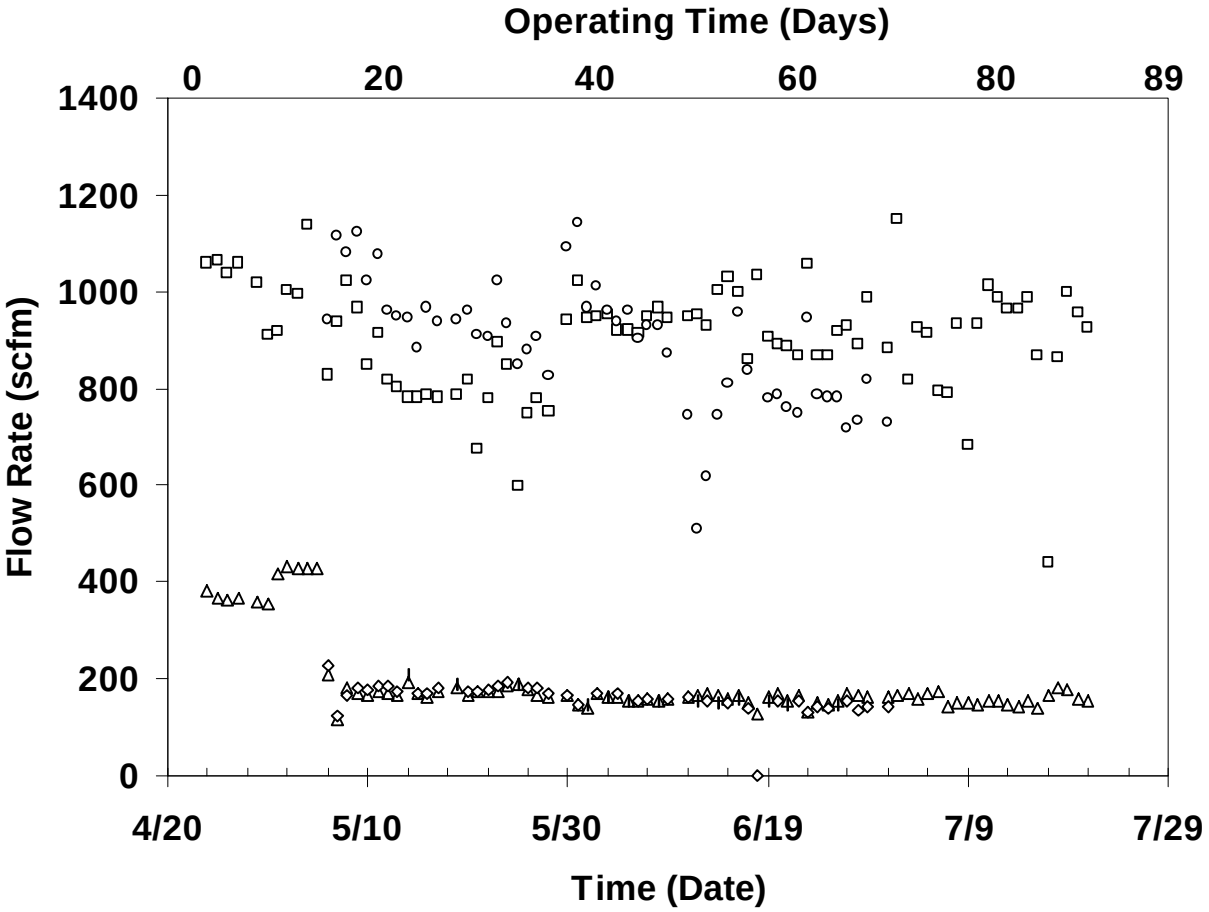
Field Data - Feed/Permeate Flow rates



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

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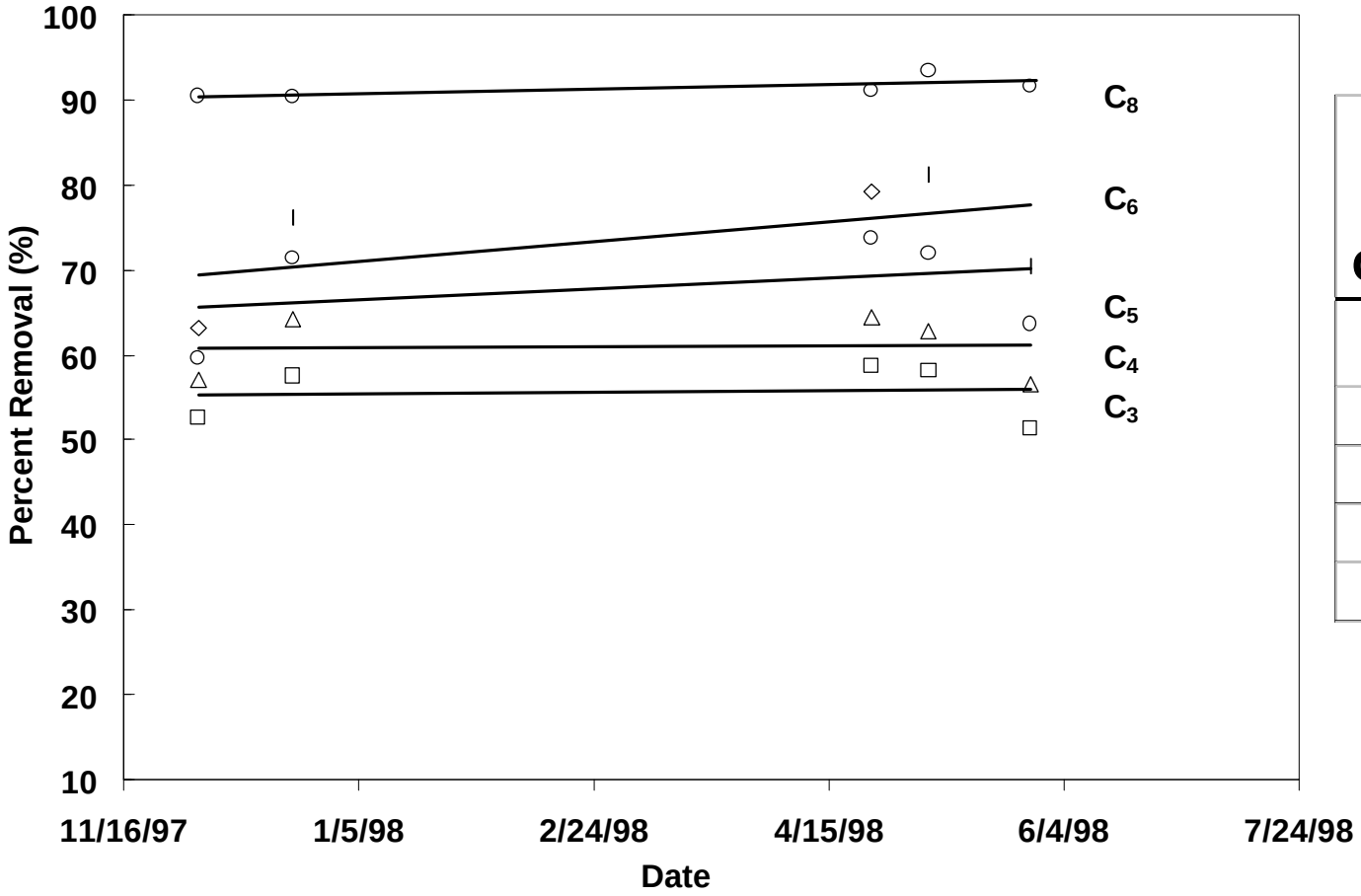
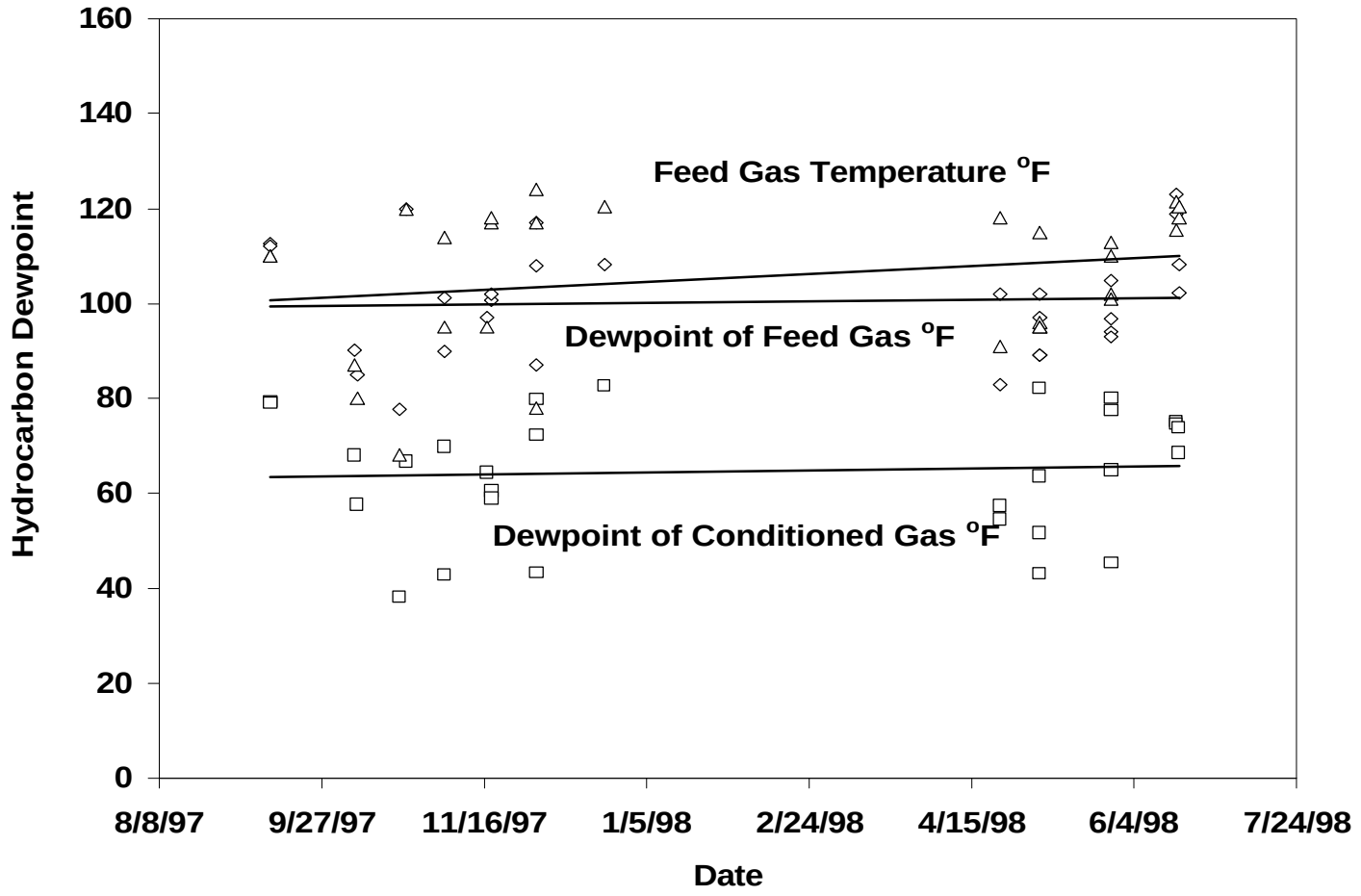
Field data - Percent Removal Rates



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

Field Data - Hydrocarbon Dewpoints



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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**

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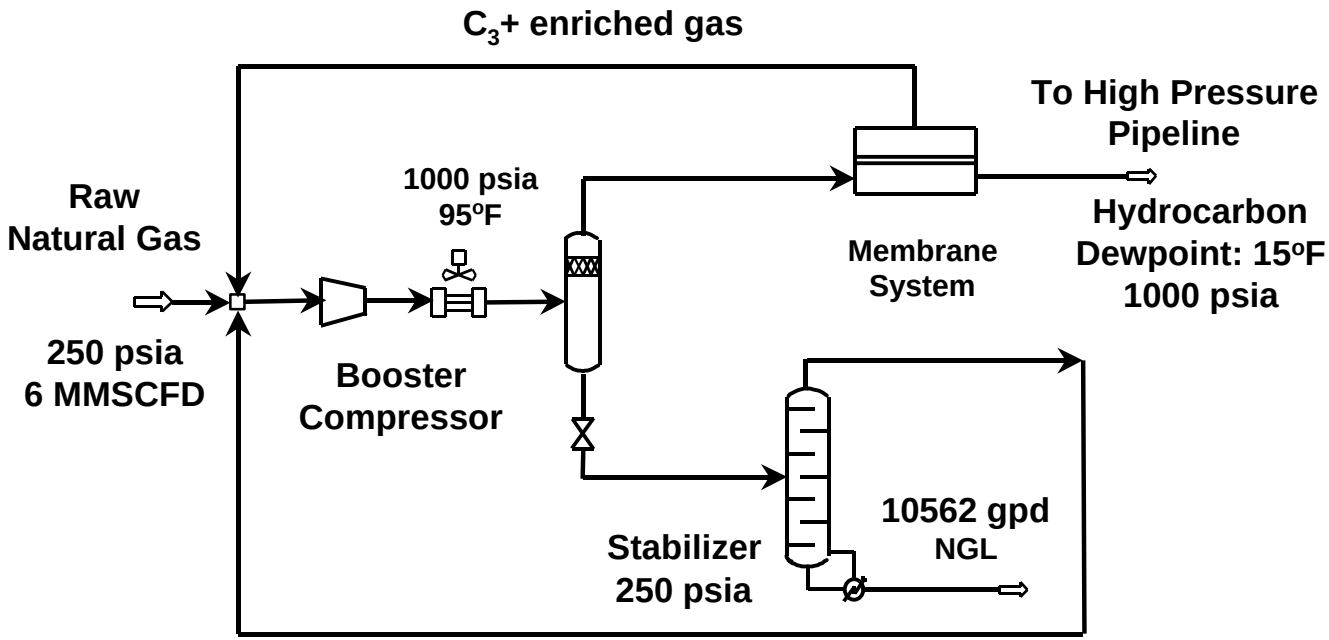
Wellhead Dewpoint Control



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

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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

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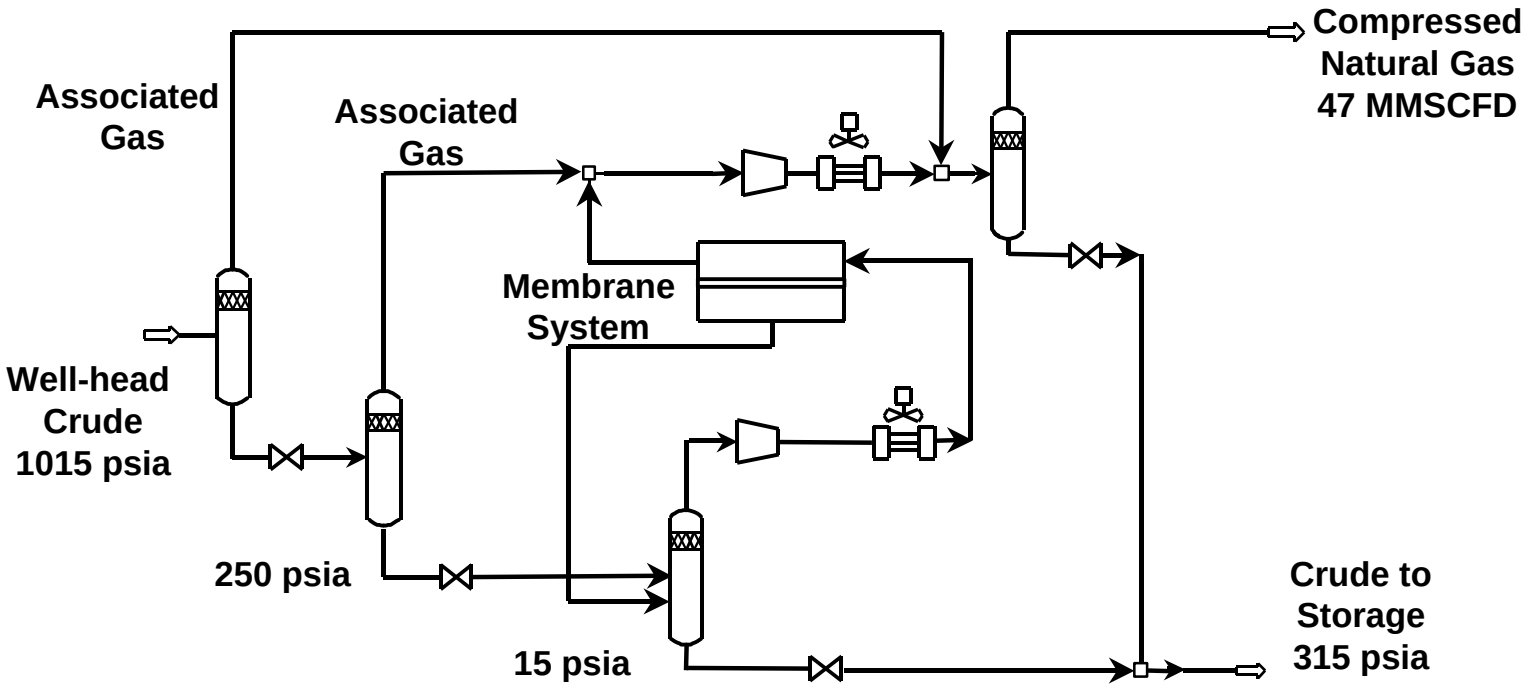
Platform Associated Gas Treatment



Increased Oil Production:	**870 Barrels/day**
Value of Additional Oil Recovered (@ $ 10/bbl):	**$ 3.0 Million/yr**
Additional Power required:	**470 hp**

Price of VaporSep System: $ 1 - 1.25 Million

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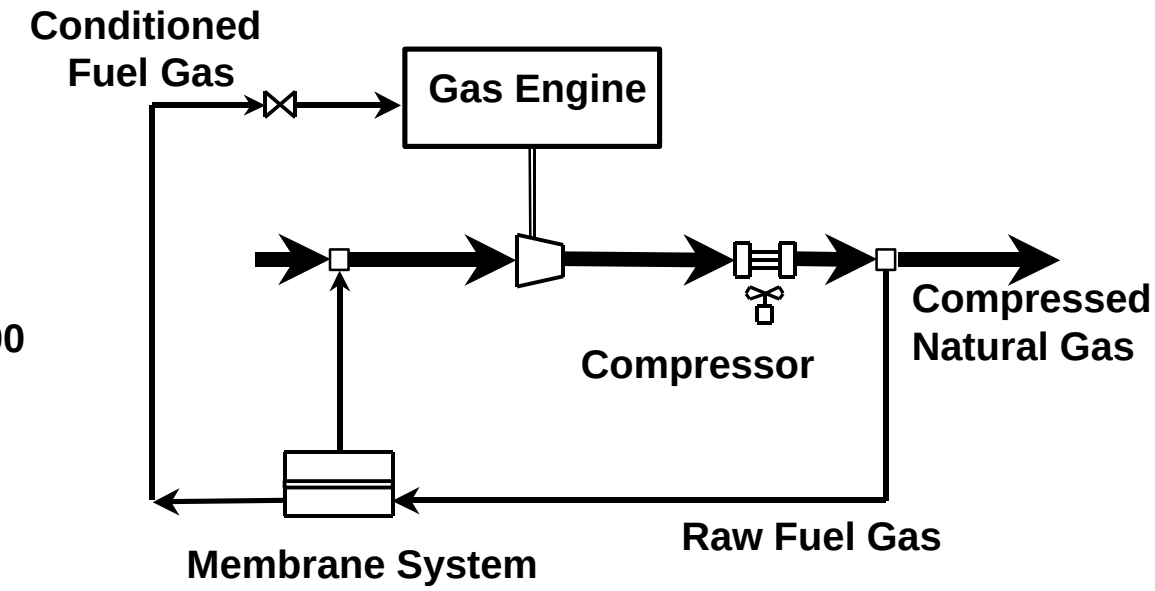
Fuel Gas Conditioning - Gas Engine Example

Membrane System Price : $150,000



Process Conditions	Membrane Feed	Conditioned Fuel Gas
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

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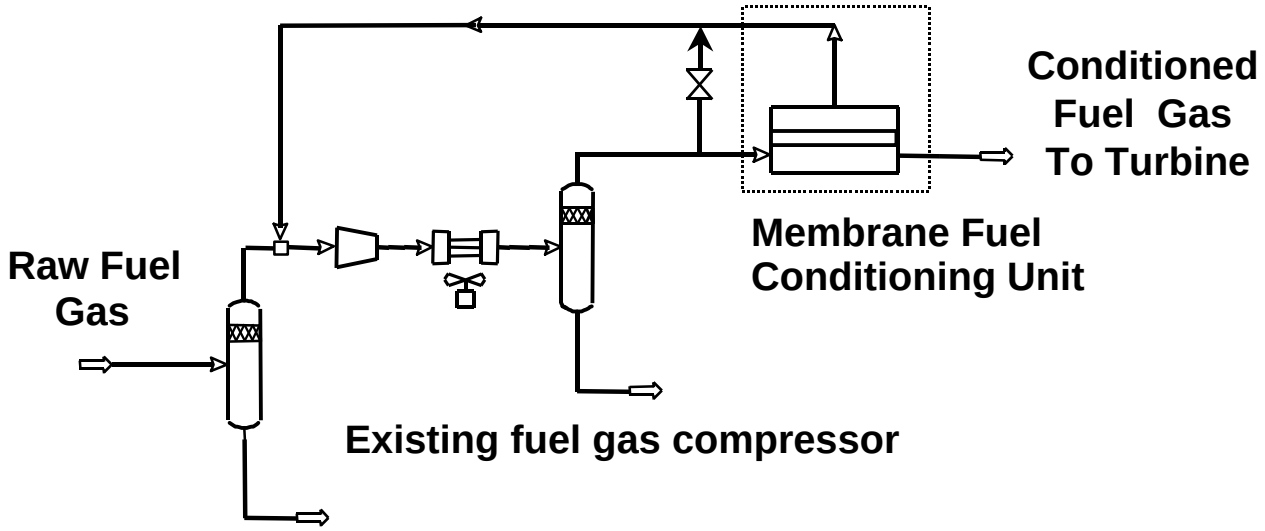
Fuel Gas Conditioning - Gas Turbine Case



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

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Typical Fuel Conditioning Skid-mounted Unit

Designed for Offshore Installation

Main System Components

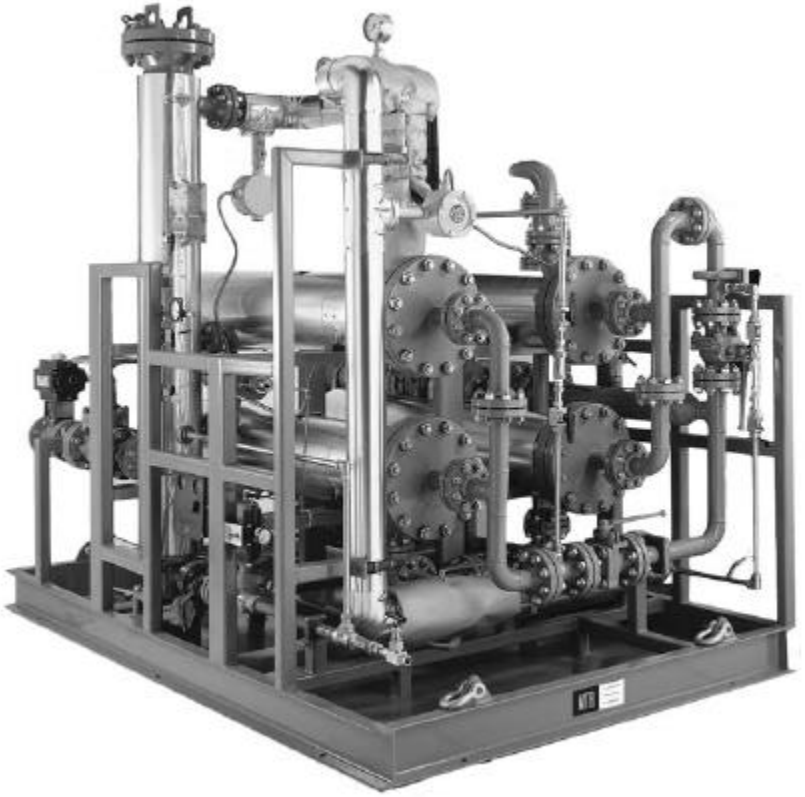
- **Membrane Modules/Housings**
- **Filter Separator/Coalescer**
- **Inlet and Discharge Valves**

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^{o}F
Conditioned Gas Dewpoint: 20^{o}F



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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**

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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.

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