

# Natural Gas Conditioning Using Membranes

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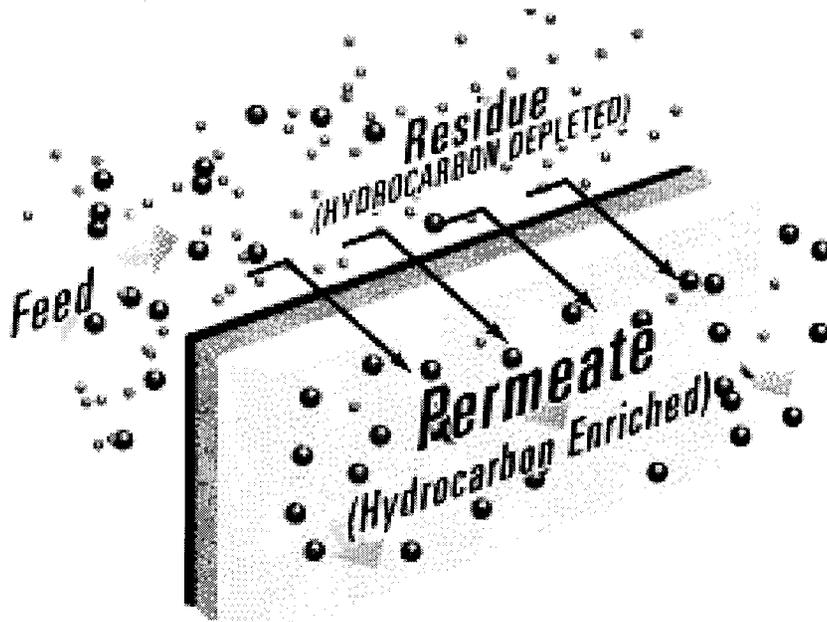
By

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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

H<sub>2</sub>O

CO<sub>2</sub>

Nitrogen

Methane

Ethane

Propane

Slow Gas

Hexane

## Rubbery Membranes

Fast Gas

Hexane

H<sub>2</sub>O

Propane

Ethane

CO<sub>2</sub>

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**

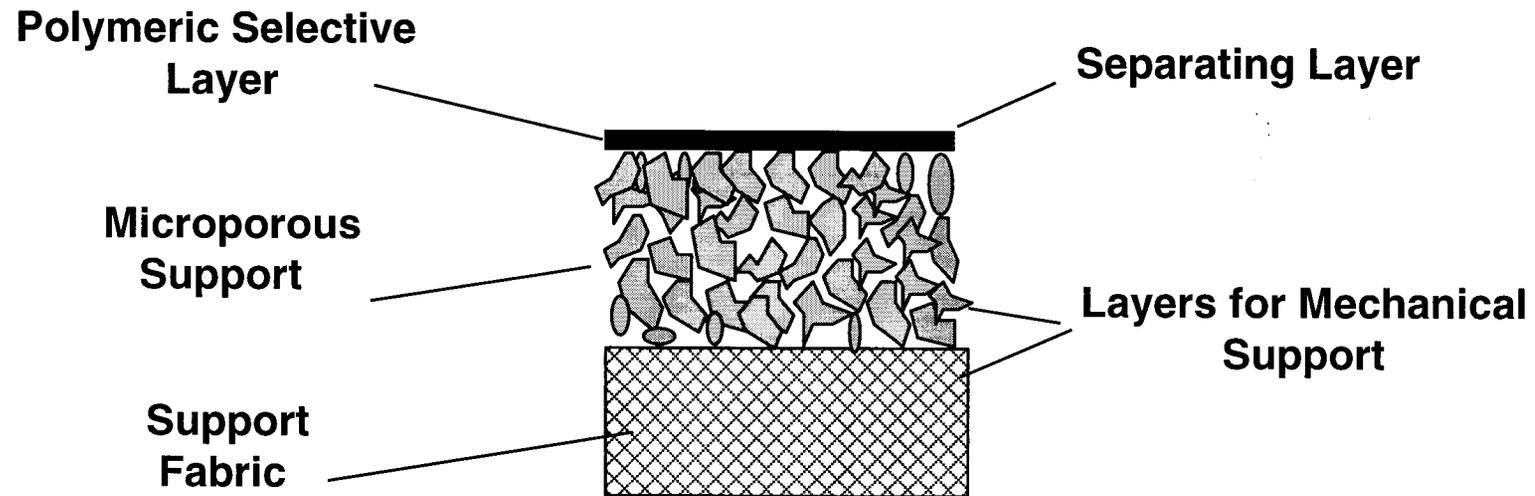
## Vapor/Gas Separation Systems

VOC/Air

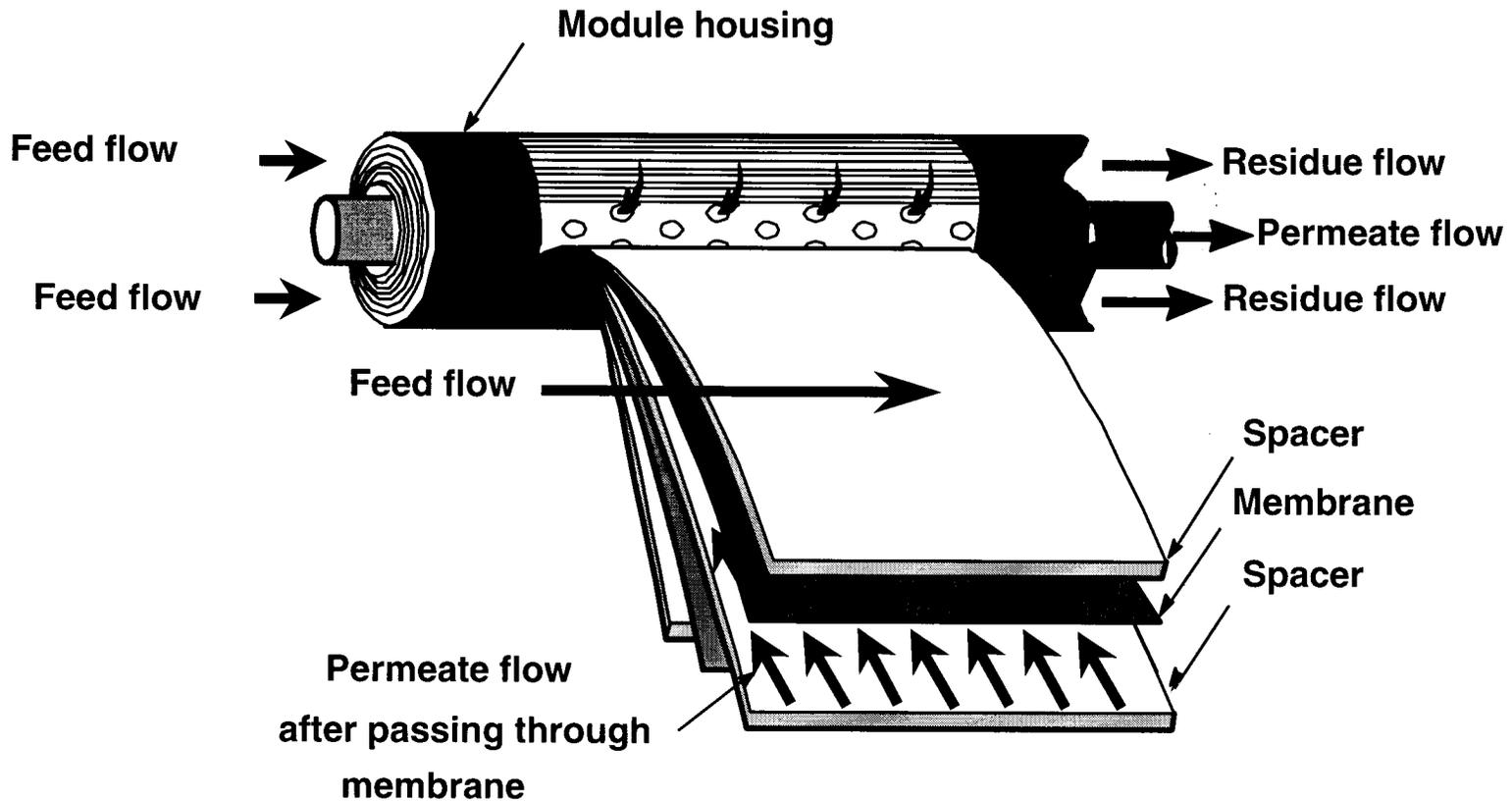
Hydrocarbon/ $N_2, CH_4$  ~ 100 Units

**Rubbery  
Membranes**

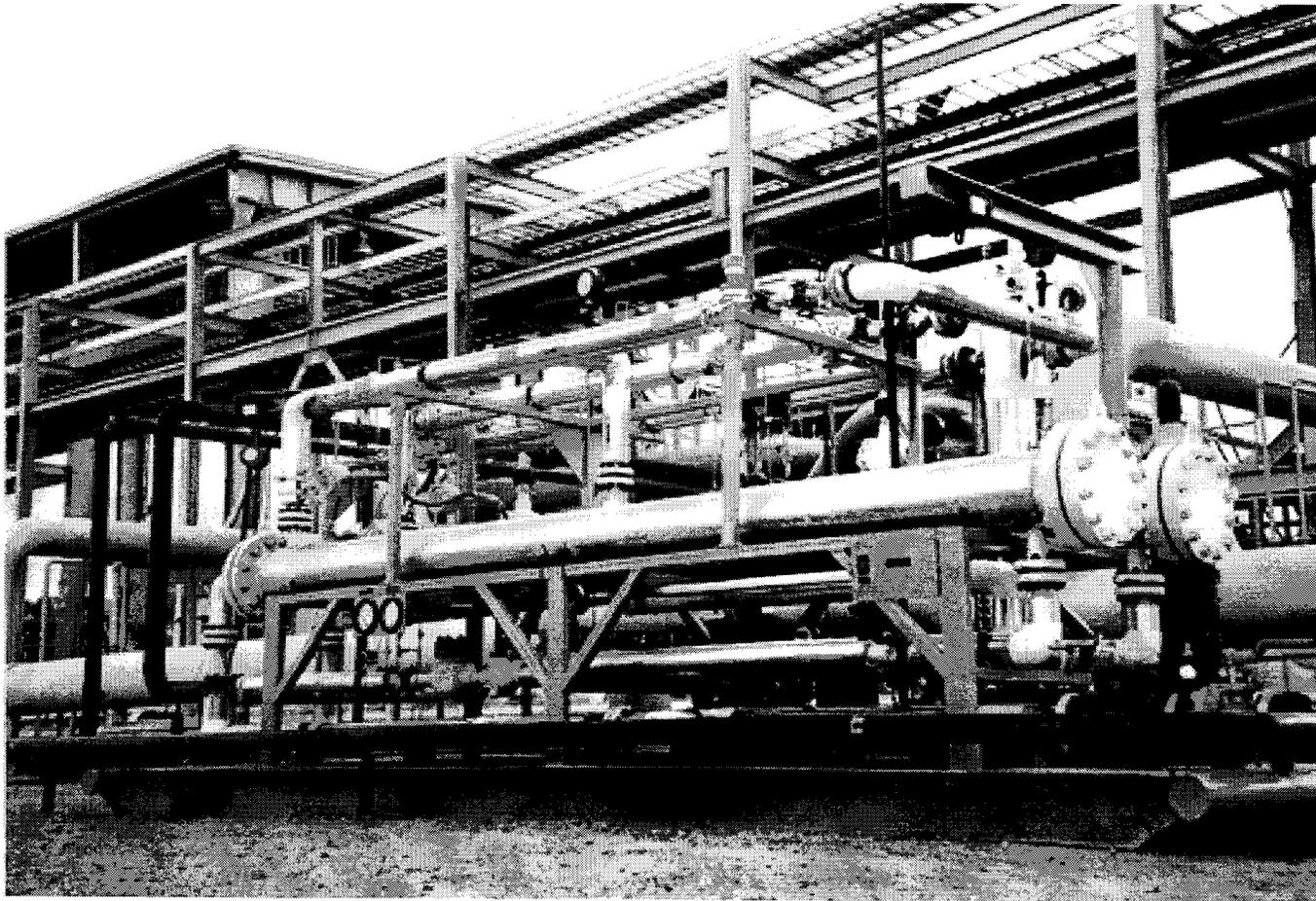
# MTR's Composite Membrane



# MTR Spiral Wound Cartridge



# NGL Separation Skid



## **Flow Capacity**

Max: 8 MMSCFD

Operated: 2.5-3.0 MMSCFD

## **Pressure rating**

Max: 1250 psig

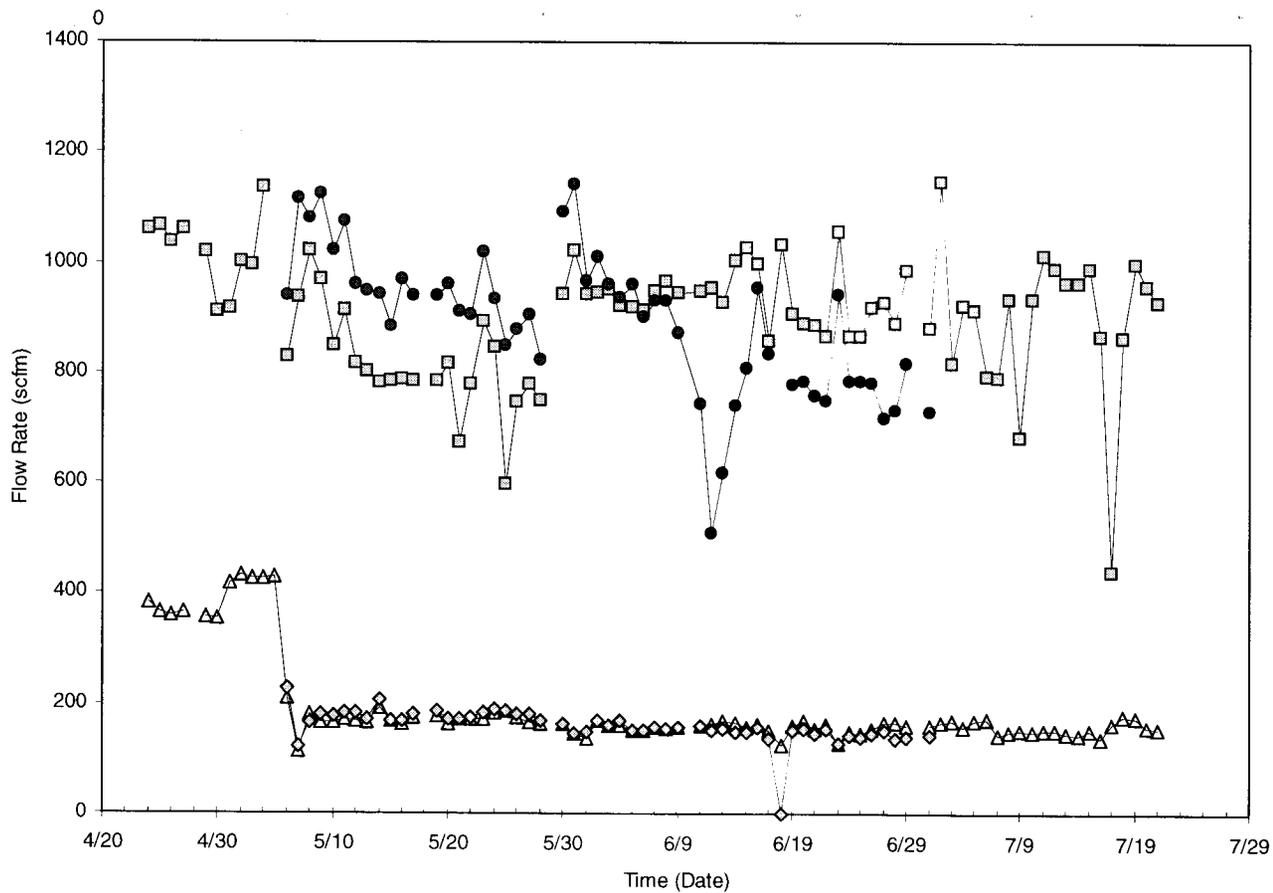
Operated: 475 psig

## **Temperature**

Max: 135°F

Operated: 100-125°F

# Field Data - Feed/Permeate Flow rates



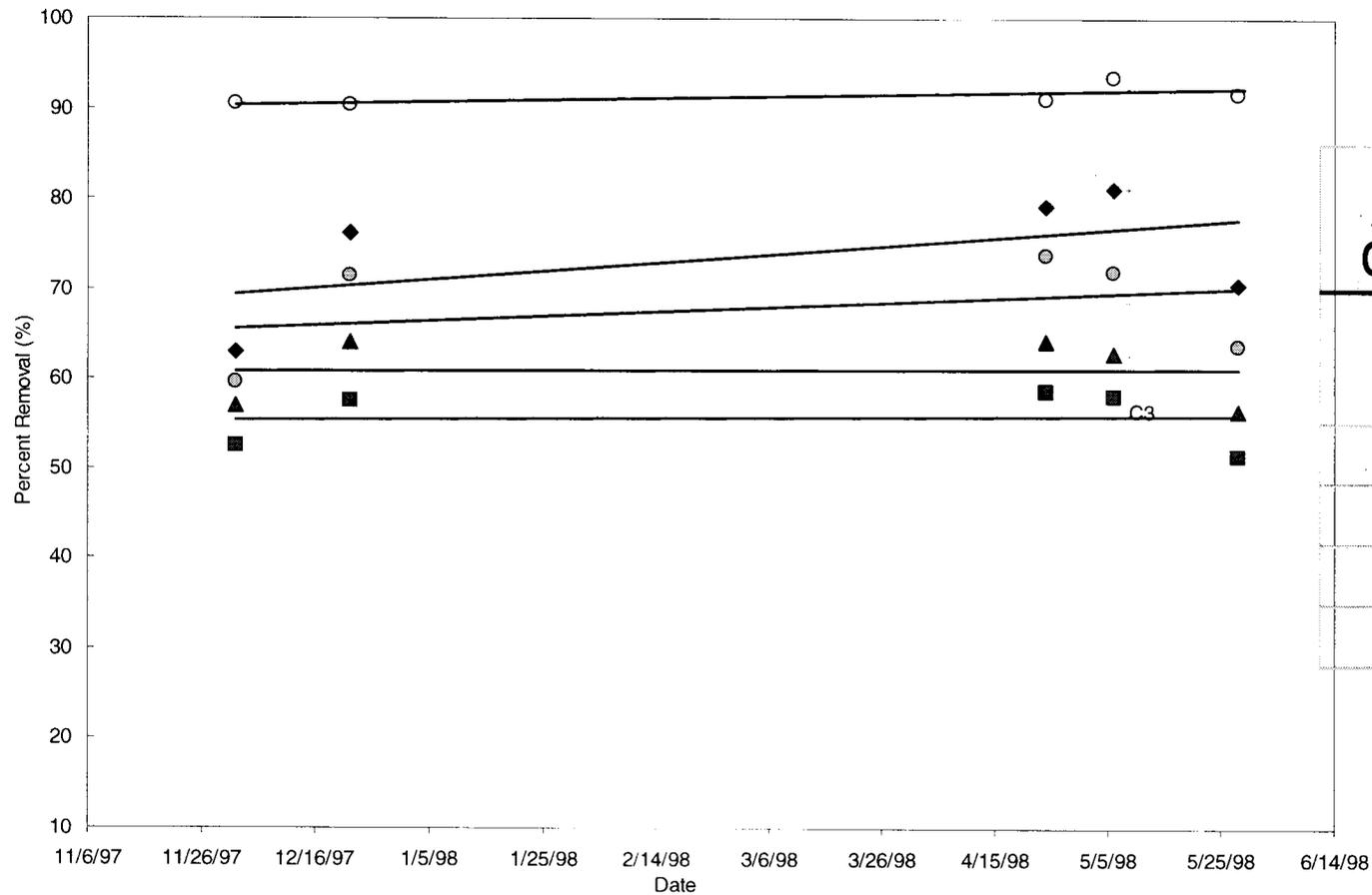
**Location: Chevron's Lost Hills Station, CA**

**Feed pressure: 450 psig**

**Avg. Feed Flow : 2.8 MMSCFD**

**Avg. Permeate Flow : 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              |

# NGL Separation and Recovery Applications

- **Well-head Gas Dewpoint Control**
- **Associated Gas Liquids Recovery**
- **Engine and Turbine Fuel Gas Conditioning**
- **Propane Refrigeration Plant Debottleneck**

# CNG Conditioning for Vehicular Use

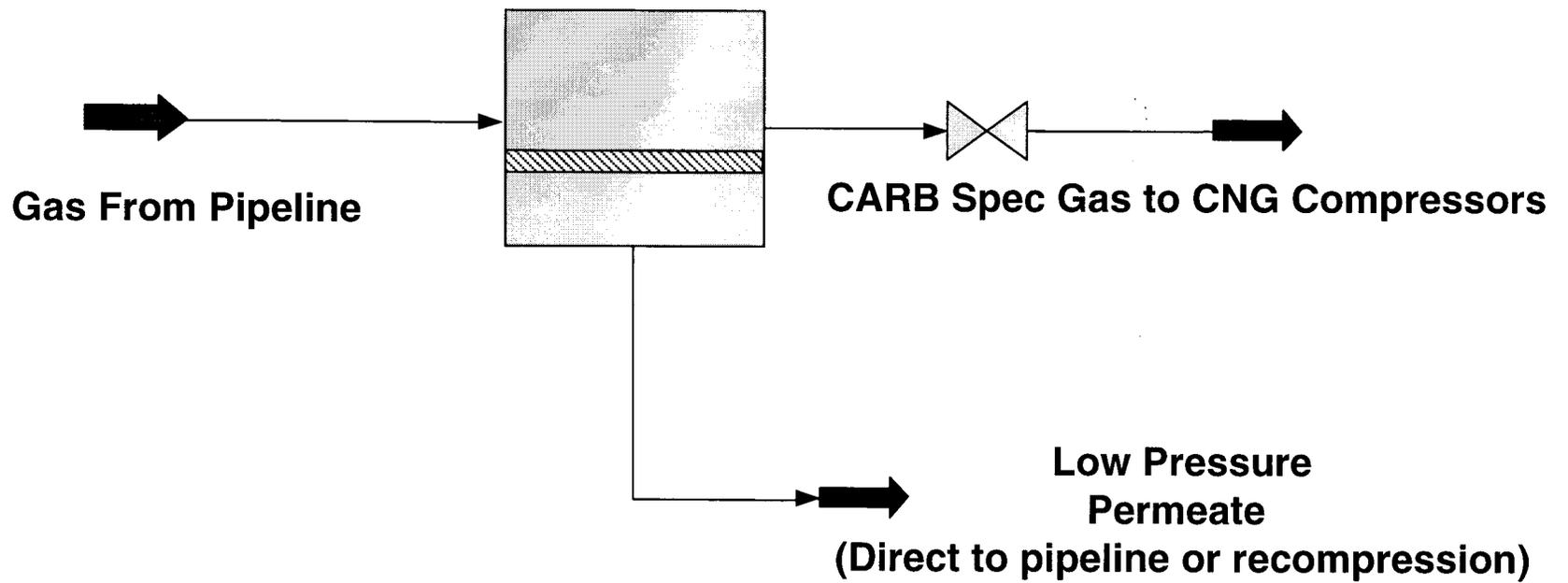
- **Current CARB Specifications**
  - ♦ Ethane < 6 mol-%
  - ♦ Propane+ < 3 mol-%
- **“Hot Gas” issue in some California counties**
- **Internal combustion gas engines have to be derated if knocking occurs. Poor gas quality is usually the problem.**

# Gas Composition Range

| Stream Type      | Concept 1<br>(Nominal) | Concept 2<br>(Ethane<br>Rich) | Concept 3<br>(Propane<br>Rich) | Concept 4<br>(Ethane And<br>Propane Rich) |
|------------------|------------------------|-------------------------------|--------------------------------|---|
| Temperature (°F) | 70                     | 70                            | 70                             | 70  |
| Pressure (psia)  | 614.7                  | 614.7                         | 614.7                          | 614.7                                     |
| Total std V scfm | 333.96                 | 336.69                        | 335.13                         | 337.96                                    |
| Component mole % |                        |                               |                                |   |
| Oxygen           | 0                      | 0                             | 0                              | 0   |
| Nitrogen         | 0.36                   | 0.35                          | 0.357                          | 0.347                                     |
| Carbon Dioxide   | 2.19                   | 2.13                          | 2.173                          | 2.114                                     |
| Methane          | 86.468                 | 84.113                        | 85.783                         | 83.464                                    |
| Ethane           | 6.149                  | 8.705                         | 6.1                            | 8.638                                     |
| Propane          | 3.449                  | 3.355                         | 4.215                          | 4.101                                     |
| I-Butane         | 0.34                   | 0.331                         | 0.337                          | 0.328                                     |
| N-Butane         | 0.71                   | 0.691                         | 0.704                          | 0.685                                     |
| I-Pentane        | 0.14                   | 0.136                         | 0.139                          | 0.135                                     |
| N-Pentane        | 0.11                   | 0.107                         | 0.109                          | 0.106                                     |
| N-Hexane         | 0.07                   | 0.068                         | 0.069                          | 0.068                                     |
| Water            | 0.014                  | 0.014                         | 0.014                          | 0.014                                     |



# Membrane Process



# Expected Membrane Performance

|  |               |               |               |               |
|--|---------------|---------------|---------------|---------------|
| <b>C<sub>2</sub> Content of Conditioned Gas (mol-%)</b>  | <b>4.1</b>    | <b>5.86</b>   | <b>4.09</b>   | <b>5.83</b>   |
| <b>C<sub>3</sub>+ Content of Conditioned Gas (mol-%)</b> | <b>2.19</b>   | <b>2.13</b>   | <b>2.55</b>   | <b>2.50</b>   |
| <b>Feed Gas Volume (scfm)</b>                            | <b>333</b>    | <b>336</b>    | <b>335</b>    | <b>338</b>    |
| <b>Product Gas Volume (scfm)</b>                         | <b>250</b>    | <b>250</b>    | <b>250</b>    | <b>250</b>    |
| <b>System Budgetary Price (US \$)</b>                    | <b>55,000</b> | <b>55,000</b> | <b>55,000</b> | <b>55,000</b> |



**Meets CARB CNG  
Specs**

# 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**

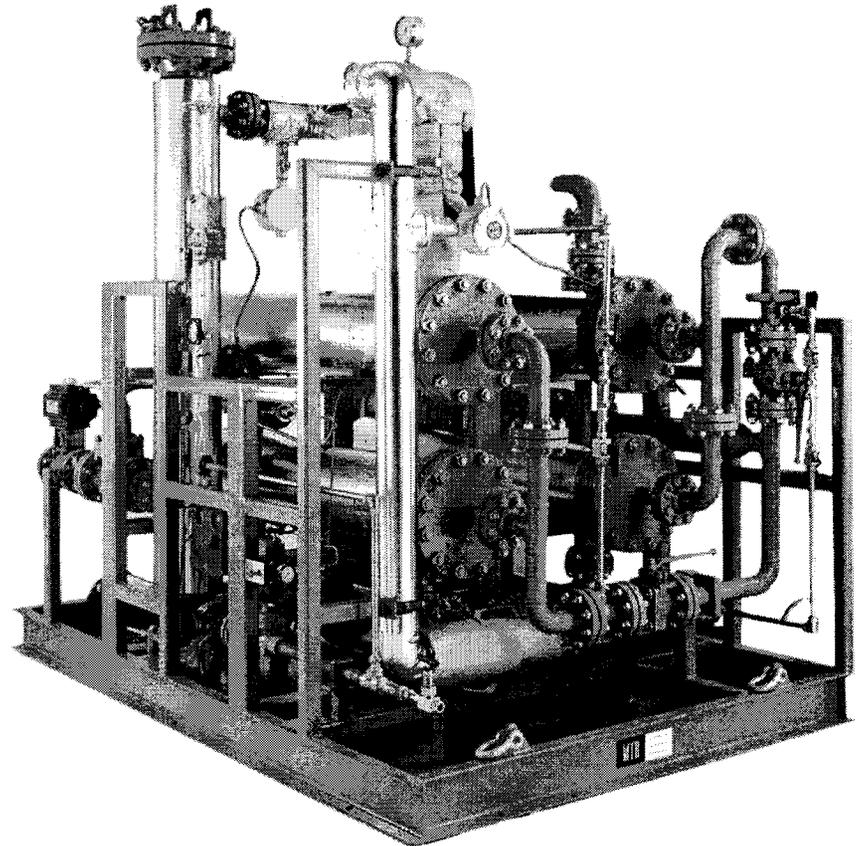
**Flow Capacity: 2.5 MMSCFD**

**Pressure rating 550 psig**

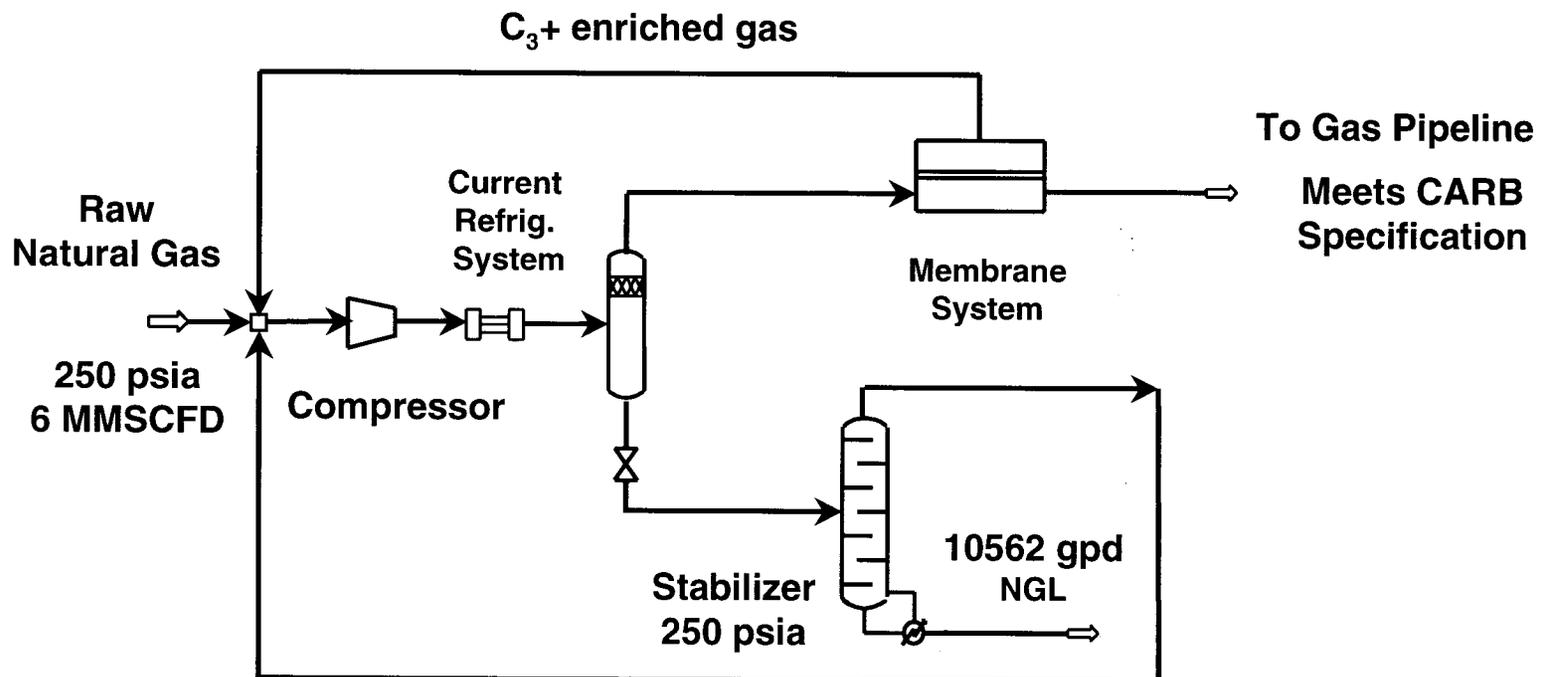
**Operating pressure: 220 psig**

**Feed hydrocarbon dewpoint: 82°F**

**Conditioned Gas Dewpoint: 20°F**



# Wellhead Gas Conditioning



**C<sub>3</sub>+ Hydrocarbons are Reduced to meet CARB Specification**

**Approximate Price of VaporSep System: \$ 500,000-1,000,000**

## 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

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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.