

# **Nitrogen-Rejecting Membranes to Increase Gas Heating Value and Recover Pipeline Natural Gas A Simple Wellhead Process Approach**

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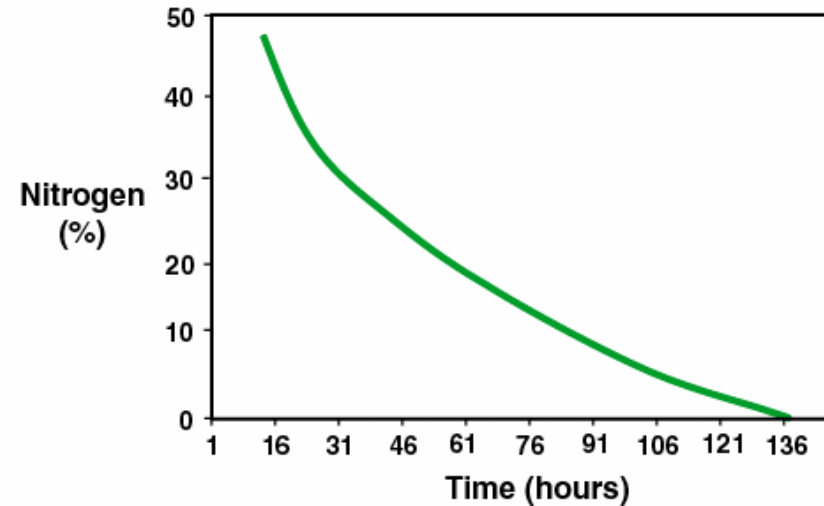
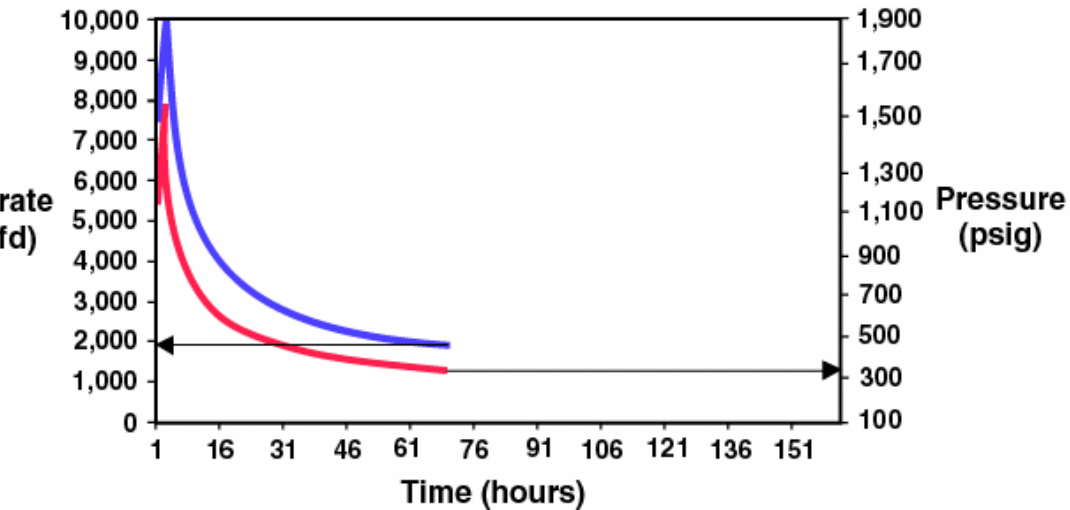
Website: [www.mtrinc.com](http://www.mtrinc.com)



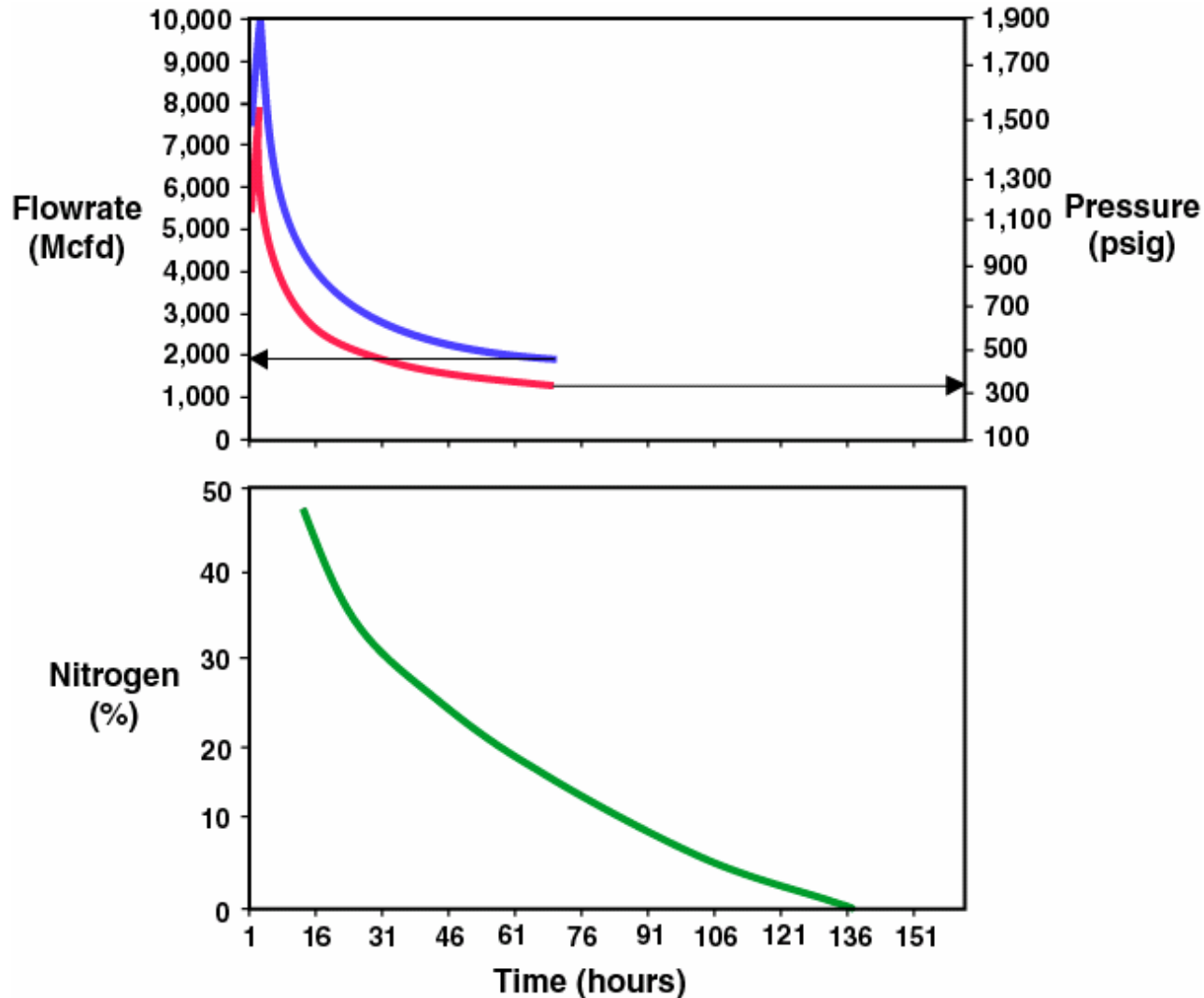
# Outline

- **Application –  
Recapturing CH<sub>4</sub> from Blow down of Nitrogen-Foam Fractured Horizontal and Vertical Wells.**
- **Novel Composite Membranes**
- **Why a Membrane Process for this Application ?**
- **Process Designs and Economics**
- **Conclusions**

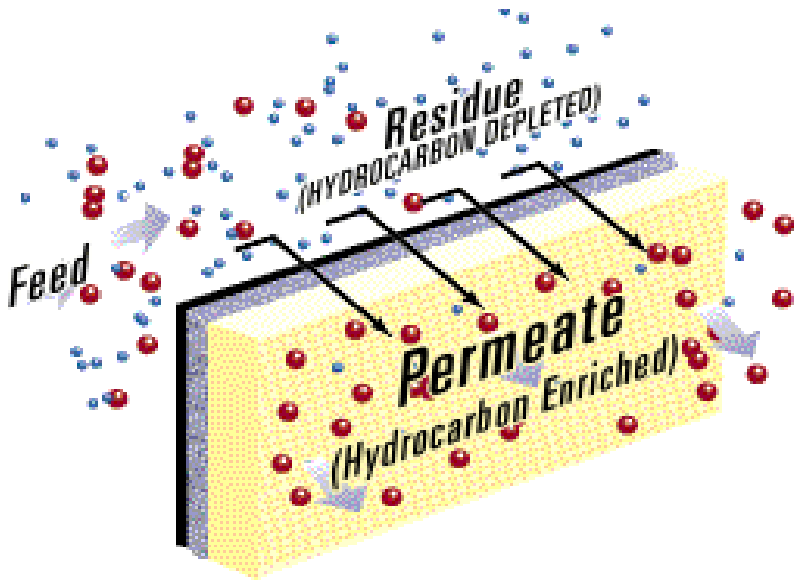
# High Rate Nitrogen-Rich Blowdown Operation in Nitrogen-Foam Fractured Horizontal Wells



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# Membrane Separation Mechanism



**MTR's Rubbery Membranes  
Reject Nitrogen  
and Permeate Hydrocarbon  
Components**

A membrane can separate components of a gas mixture due to differential permeation rates across a non-porous polymer film resulting in a differential pressure driving force.

$$\text{Permeability} = \text{Diffusivity} * \text{Solubility}$$

(P) (D) (S)

**Membrane Selectivity**

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

# Glassy versus Rubbery Membranes

## Glassy Membranes

**Fast Gas**

Hydrogen

H<sub>2</sub>O

CO<sub>2</sub>

Nitrogen

Methane

Ethane

Propane

Hexane

**Slow Gas**



## Rubbery Membranes (MTR Technology)

**Fast Gas**

Hexane

H<sub>2</sub>O

Propane

Ethane

CO<sub>2</sub>

Methane

Hydrogen

Nitrogen

**Slow Gas**



# Membrane System Installations

## Membranes are a Mature Separation Technology

### Gas/Gas Separation Systems

**H<sub>2</sub>/N<sub>2</sub>, CH<sub>4</sub> ~ 200 Units**

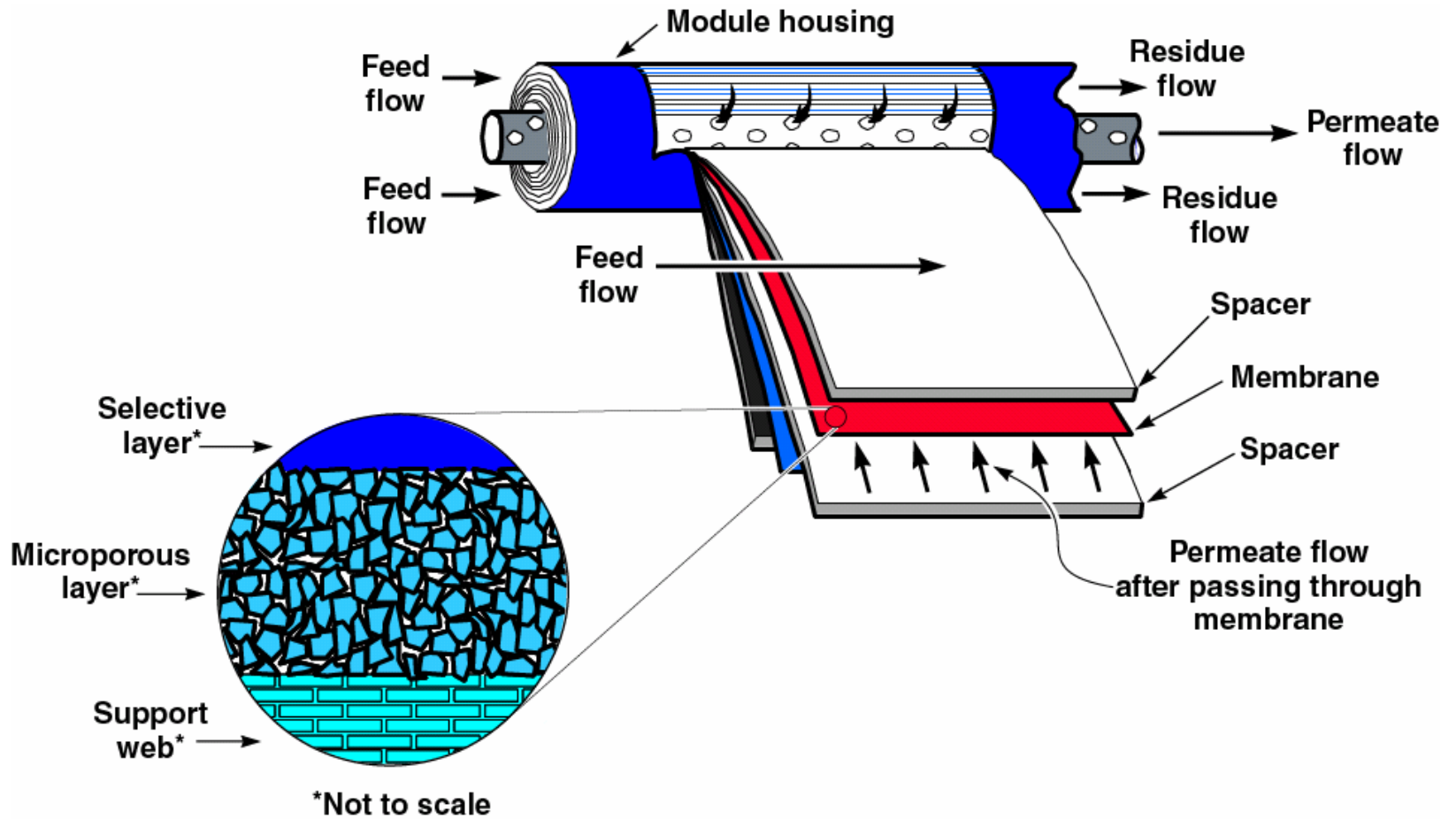
**O<sub>2</sub>/N<sub>2</sub> ~ 5,000 Units**

**CO<sub>2</sub>/CH<sub>4</sub> ~ 200 Units**

### Vapor/Gas Separation Systems (MTR'S Reference Base)

**Hydrocarbon/N<sub>2</sub>, CH<sub>4</sub> ~ 100 Units**

# MTR Membrane in Spiral Wound Cartridges





# Typical Commercial Skid-Mounted Unit



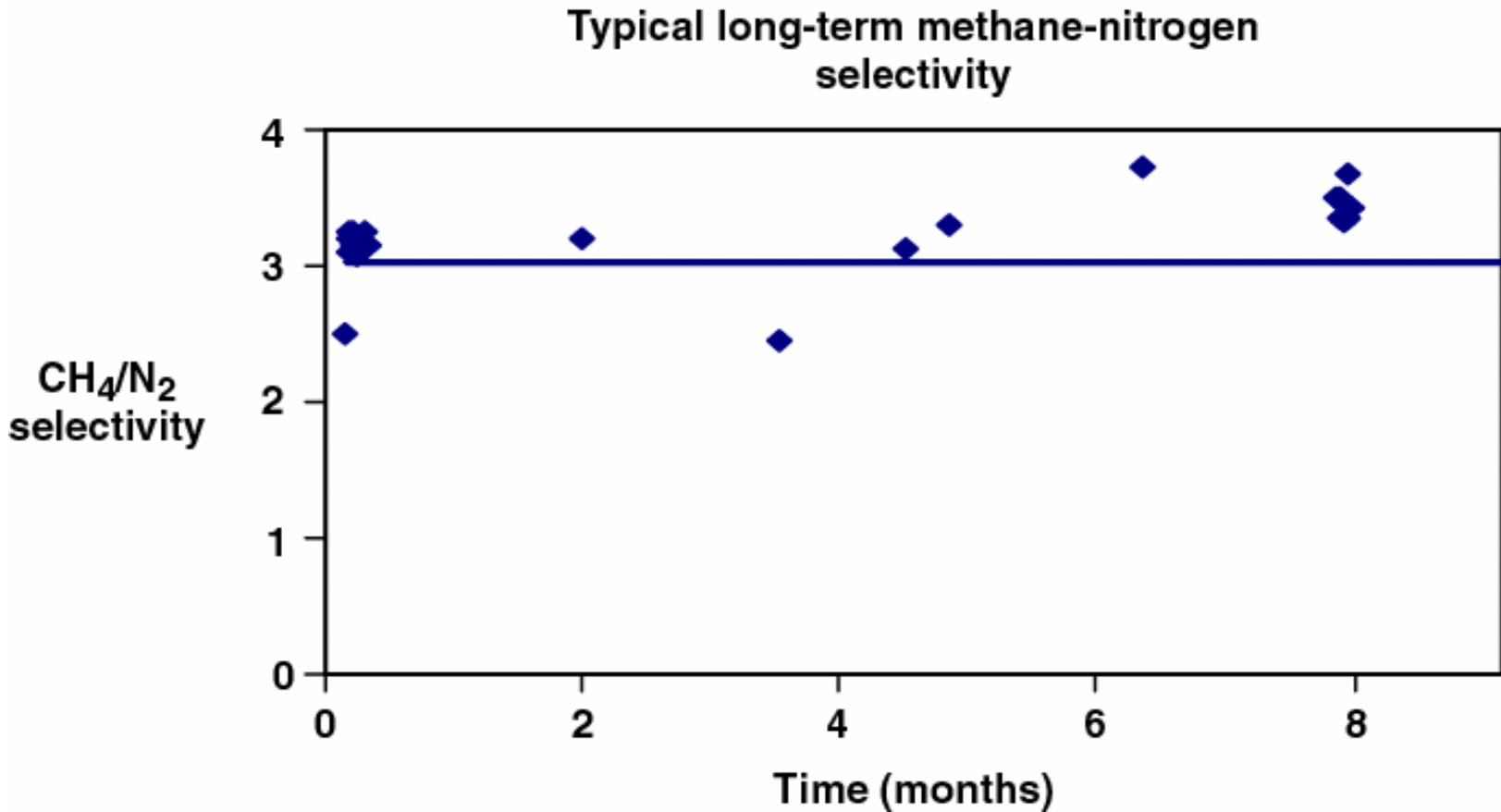
**Twin Bottoms Membrane System  
Design Flow Rate-0.2 MMSCFD**



**NTE Membrane System  
Design Flow Rate-1.0 MMSCFD**

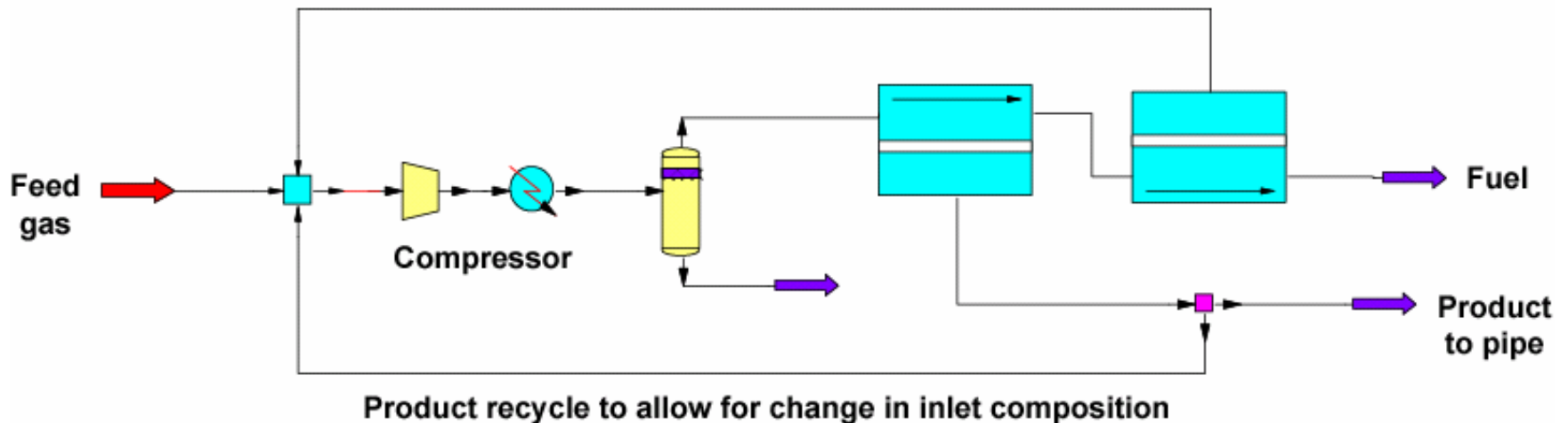


# Proven Long-Term Separation Efficiency (400 years Cumulative Operating Experience with Silicone Rubber Membrane)



# Process Flow Diagram for Vertical Wells

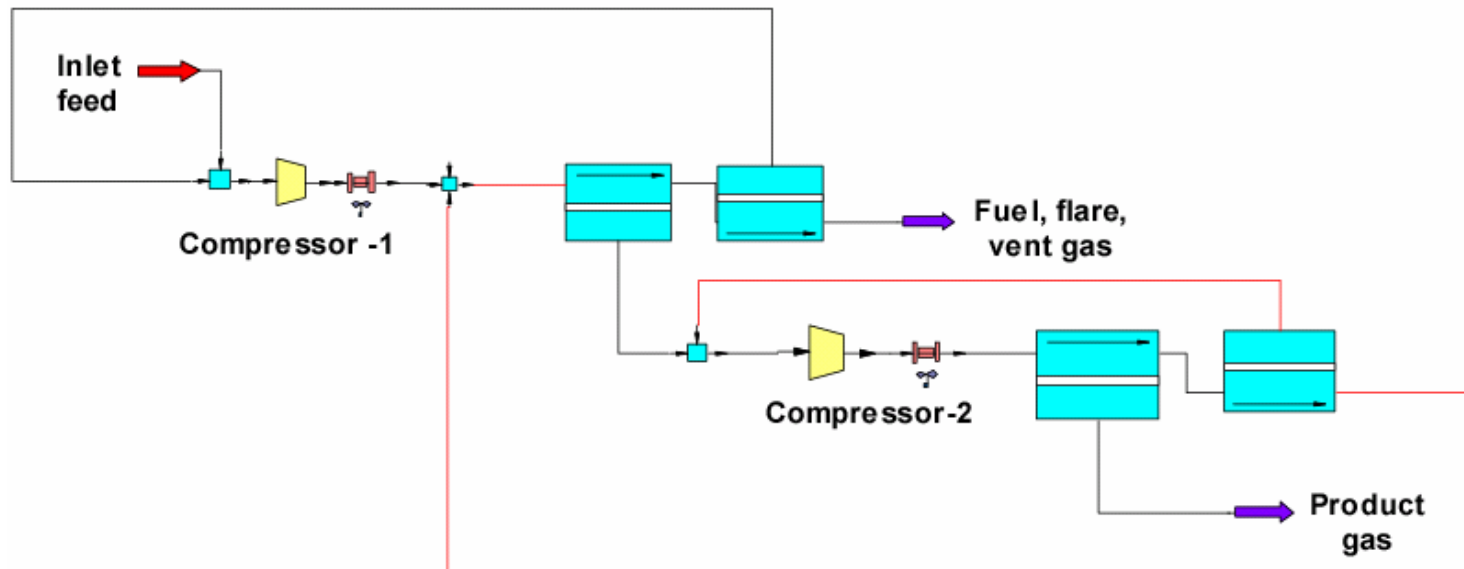
15% inlet nitrogen content  
< 4 mol% product nitrogen content  
Btu enhancement from 830 to 970 Btu/scf



Feed gas flow rate:	0.500 MMSCFD
Feed gas nitrogen content:	15 mol%
Pipeline gas nitrogen content:	4 mol%
Annual net revenue:	\$US 600,000
Annual operating expenses:	\$US 165,000
Simple payback period:	9 months
Membrane system price:	\$US 350,000

# Process Scheme for High Nitrogen Feed Gas from Horizontal Wells

12-30 mol% nitrogen in inlet gas  
< 4 mol% nitrogen in product gas  
Btu enhancement from 783 to 890 Btu/scf



Feed gas flow rate:	3.5 MMSCFD
Feed gas nitrogen content:	31 mol%
Pipeline gas nitrogen content:	10 mol%
Annual net revenue:	\$US 3.5 million
Annual operating expenses:	\$US 515,000
Simple payback period:	6 months
Membrane system price:	\$US 620,000 - 720,000

# Nitrogen Rejection – Application Envelope

- **Inlet nitrogen content between 4 and 30 vol%**
- **Inlet flow rate between 0.1 – 20 MMSCFD**
- **Discharge N<sub>2</sub> specification between 4 and 8 vol%**
- **Upgrading to pipeline acceptability**
- **Upgrading fuel gas to meet heating value for burning**
- **Hydrocarbon removal for nitrogen re-injection**
- **Mobile units can be manufactured easily**

# Advantages of Membrane Systems

- **Simple passive system**
- **High on-stream factor (typically > 98%)**
- **Minimal or no operator attention**
- **Small footprint, low weight**
- **Large turndown ratio**
- **Low maintenance**
- **Lower capital and operating costs**
- **Units are mobile. No foundation required. Level gravel or soil is adequate for membrane skid.**

# Other Oil & Gas Applications

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## Other Applications in the Oil & Gas Industries for MTR's Reverse-Selective Membranes

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**Gas:** Fuel gas conditioning  
NG Dew point Control  
NGL recovery  
Natural gas dehydration.

**Oil:** Associated gas processing  
Vapor recovery from storage tanks and ship vents.