Membrane Systems for Nitrogen Rejection

By

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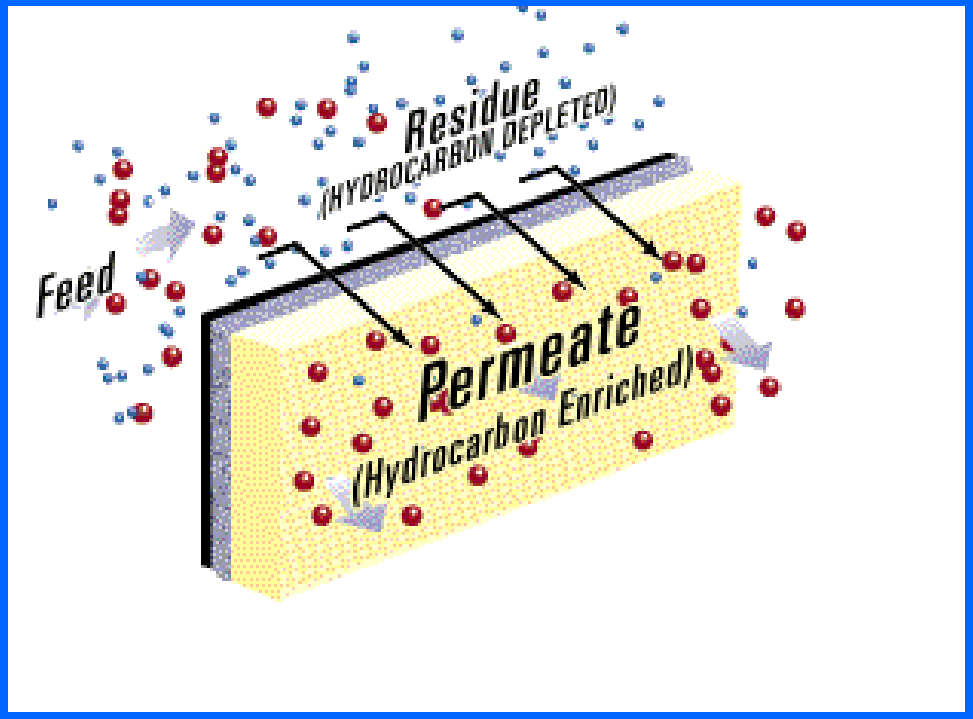
Membrane Separation Mechanism



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 Nitrogen and permeate hydrocarbon components

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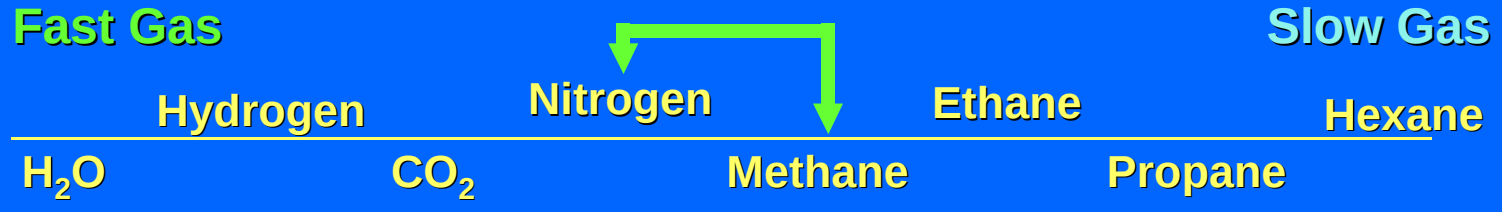
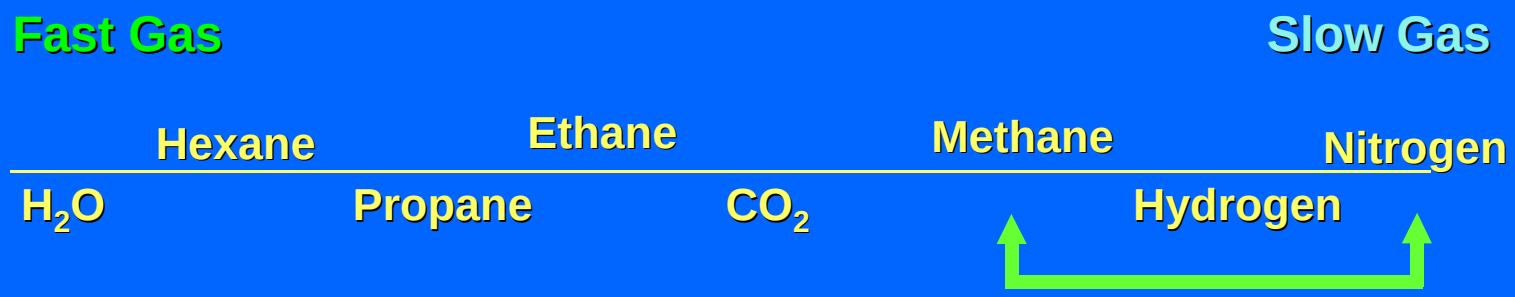
Glassy v/s Rubbery Membranes

Glassy Membranes



Rubbery Membranes



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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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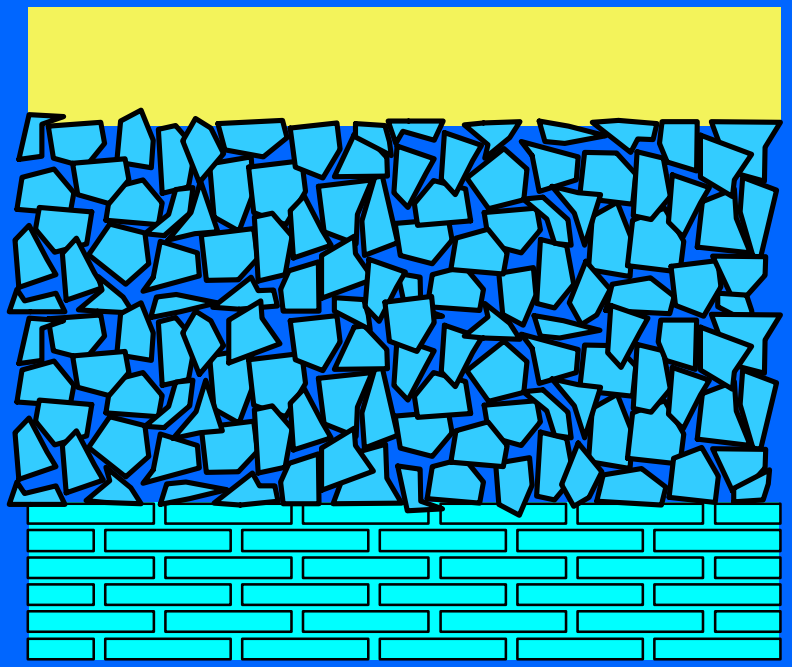
MTR's Composite Membrane



Selective layer

Microporous layer

Support web

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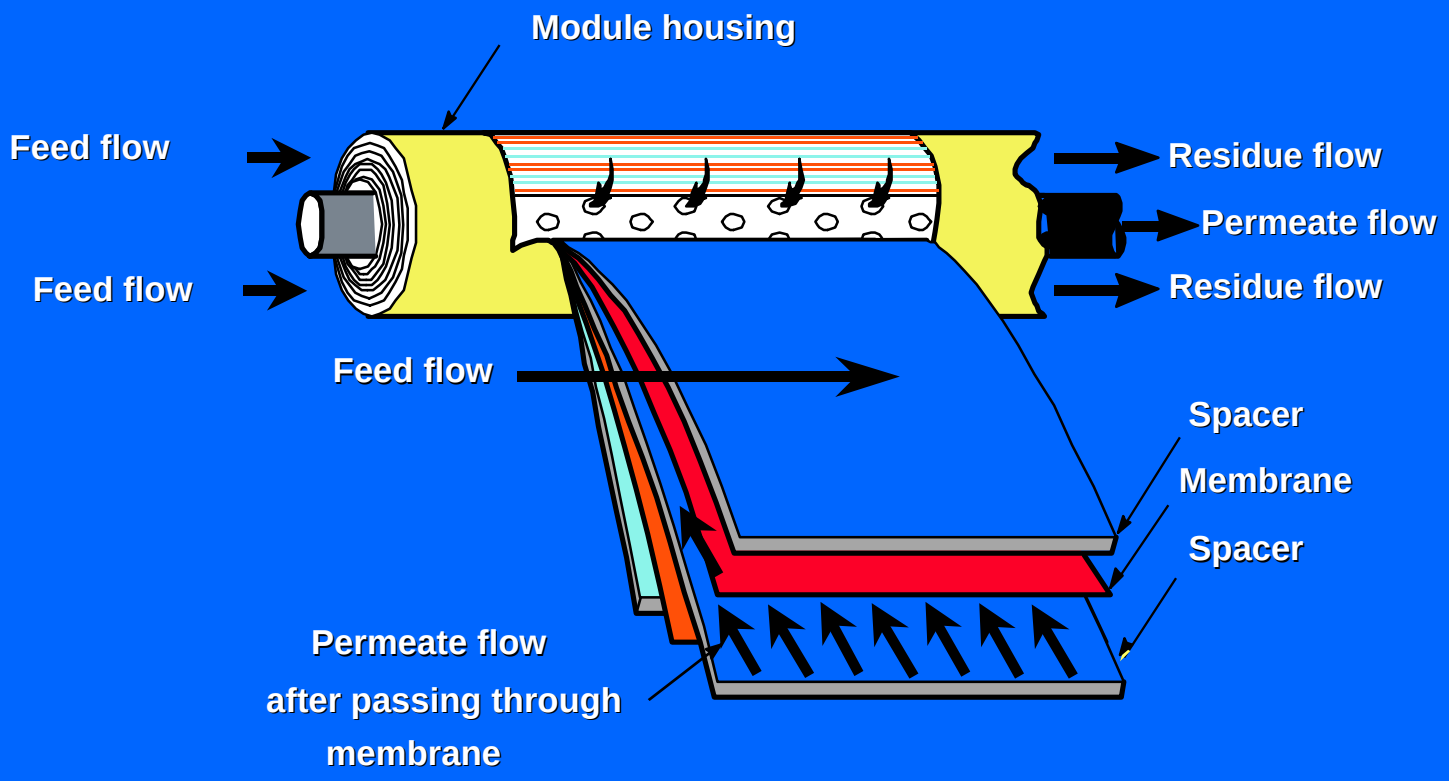
MTR Spiral Wound Cartridge



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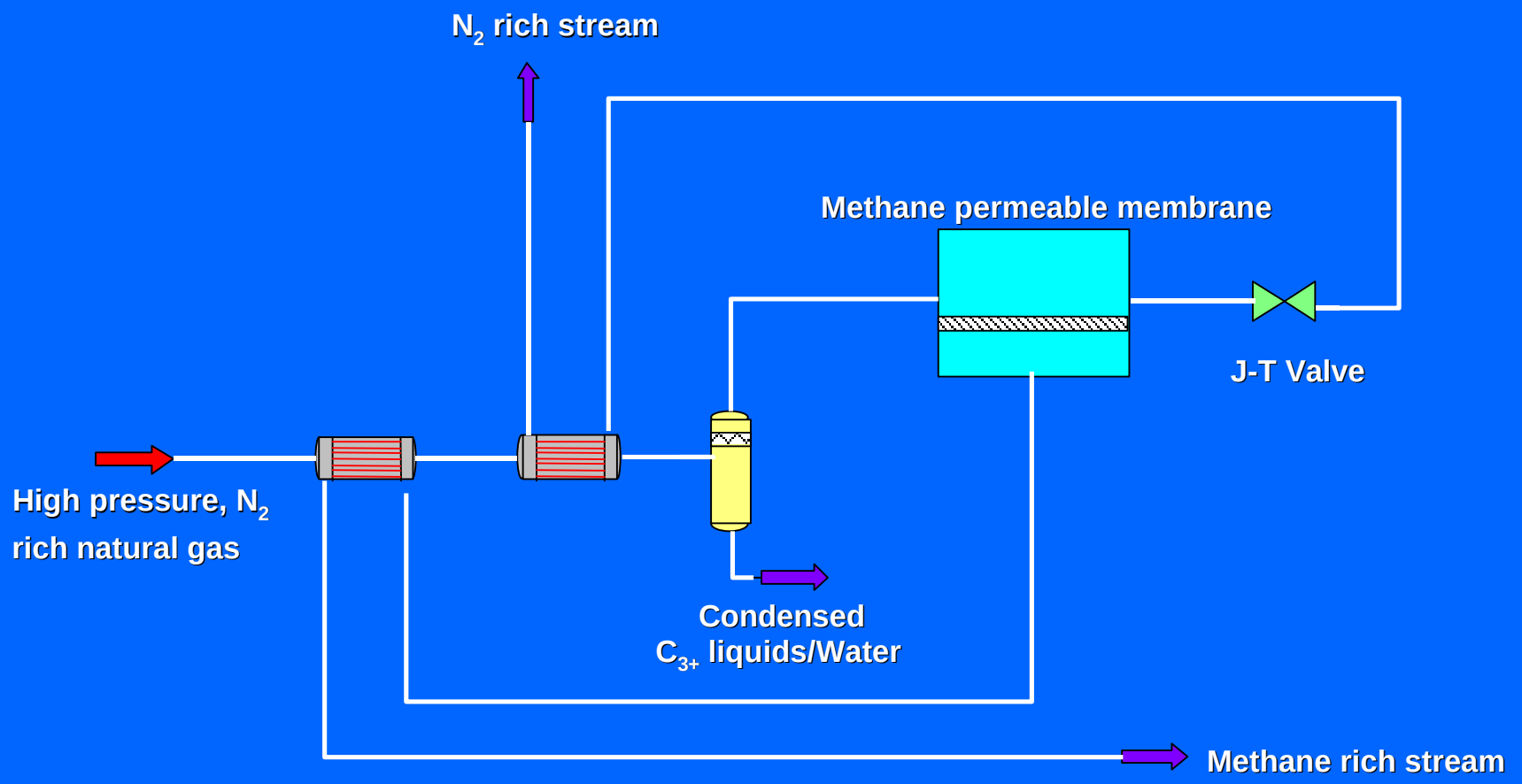
Field Test Unit Process Diagram



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Nitrogen Rejection Test System

Flow Capacity
Max: 0.2 MMSCFD
Operated: 0.1-0.2 MMSCFD

Pressure rating
Max: 1250 psig
Operated: 400-600 psig

Temperature
Max: 135ºF
Operated: 15-50ºF

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Field Test – Inlet Gas Composition

Component	Composition (mole%)
Methane	75.0
Ethane	2.8
Propane	1.0
Butane	0.4
Pentane and heavier	0.1
Water	1.7
Nitrogen	19.0

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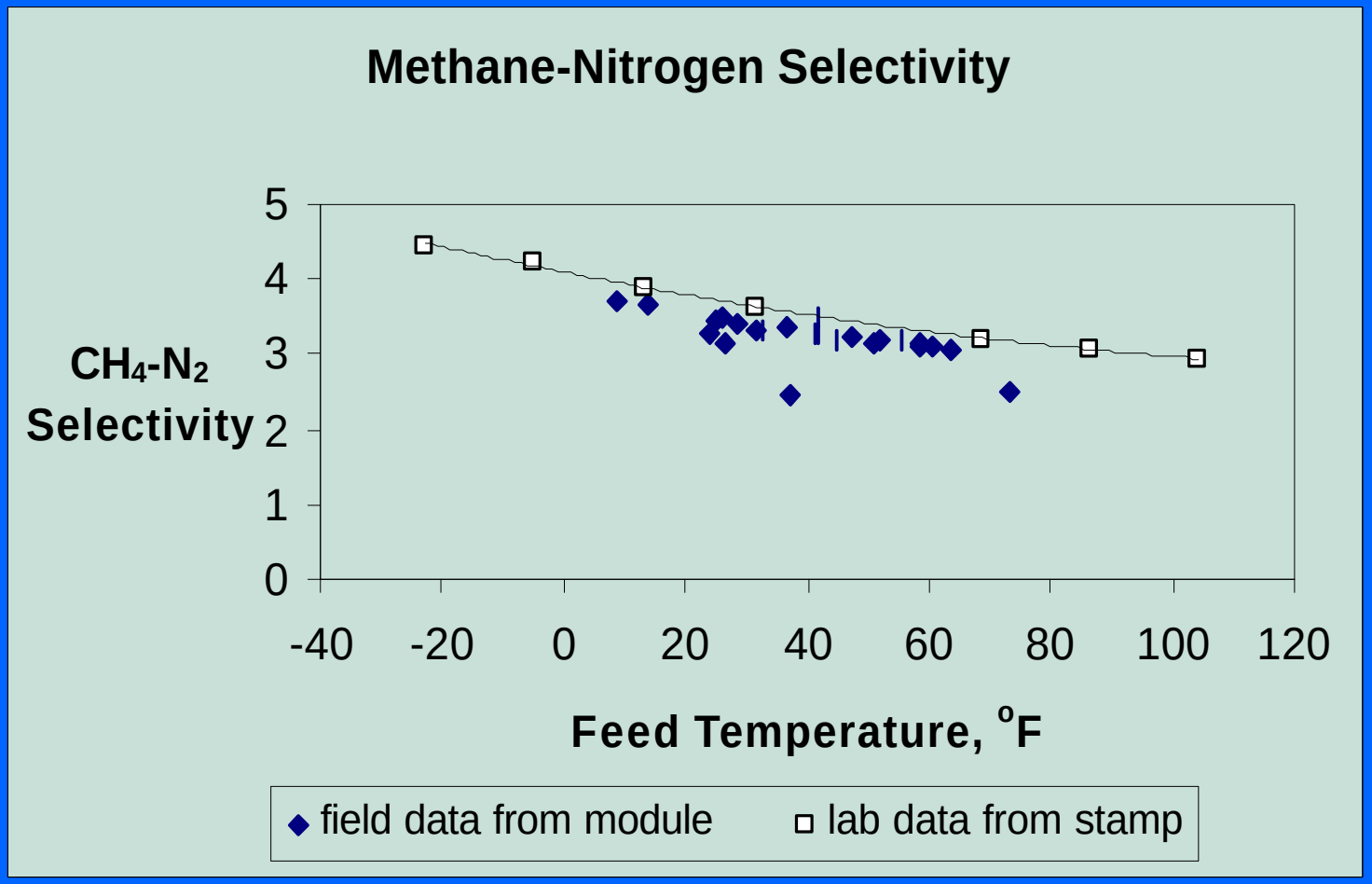
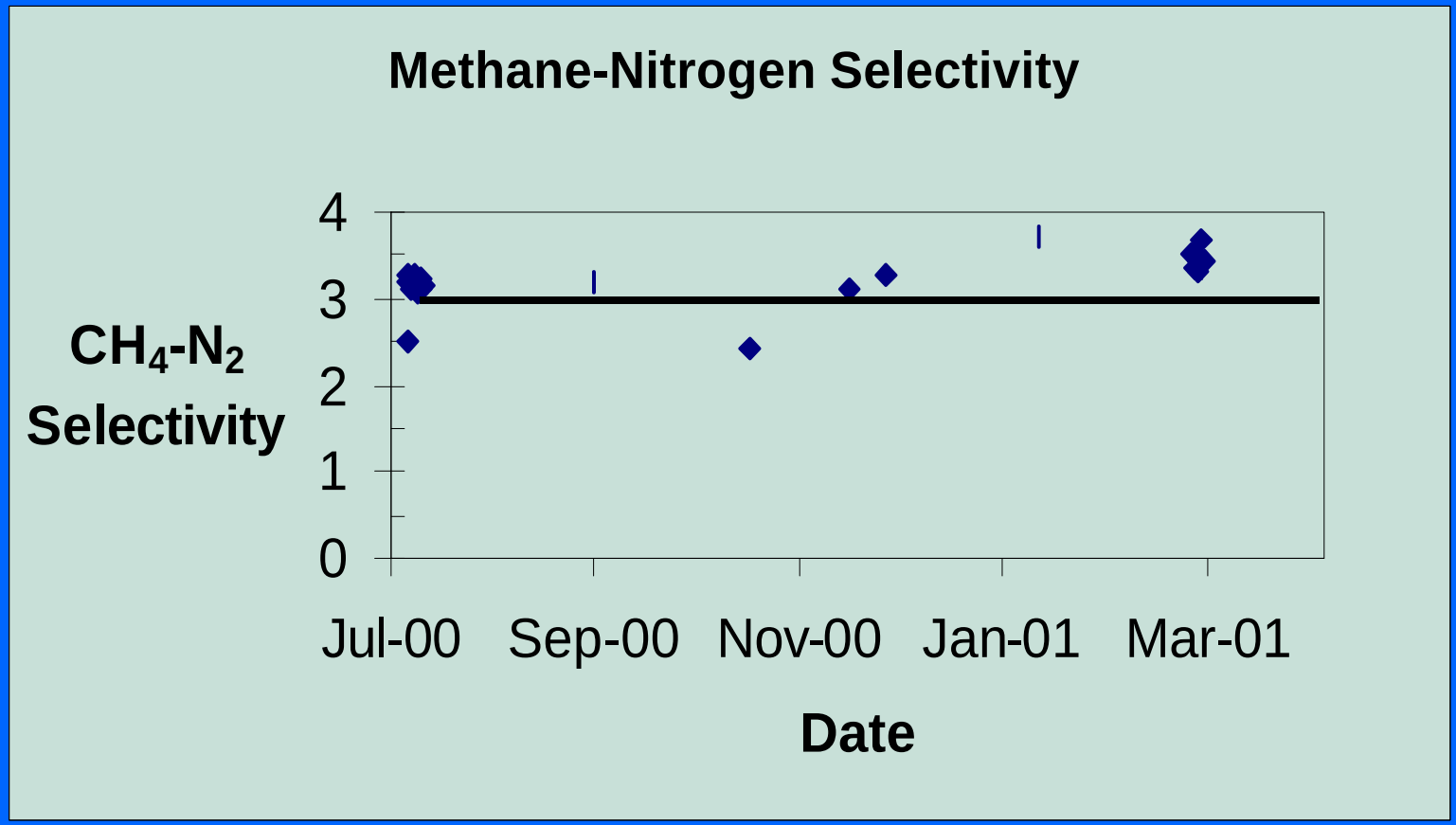
Comparison of Lab and Field Data



Long Term Separation Efficiency



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Nitrogen Rejection – Application Envelope

- **Inlet Nitrogen Content between 4 and 20 vol-%**
- **Inlet flow rate between 0.1 – 20 MMSCFD**
- **Discharge N_2 specification between 4 and 8 vol-%**
- **Upgrading to Pipeline acceptability**
- **Upgrading fuel gas to meet BTU-Value for Burning**
- **Hydrocarbon Removal for Nitrogen Re-injection**

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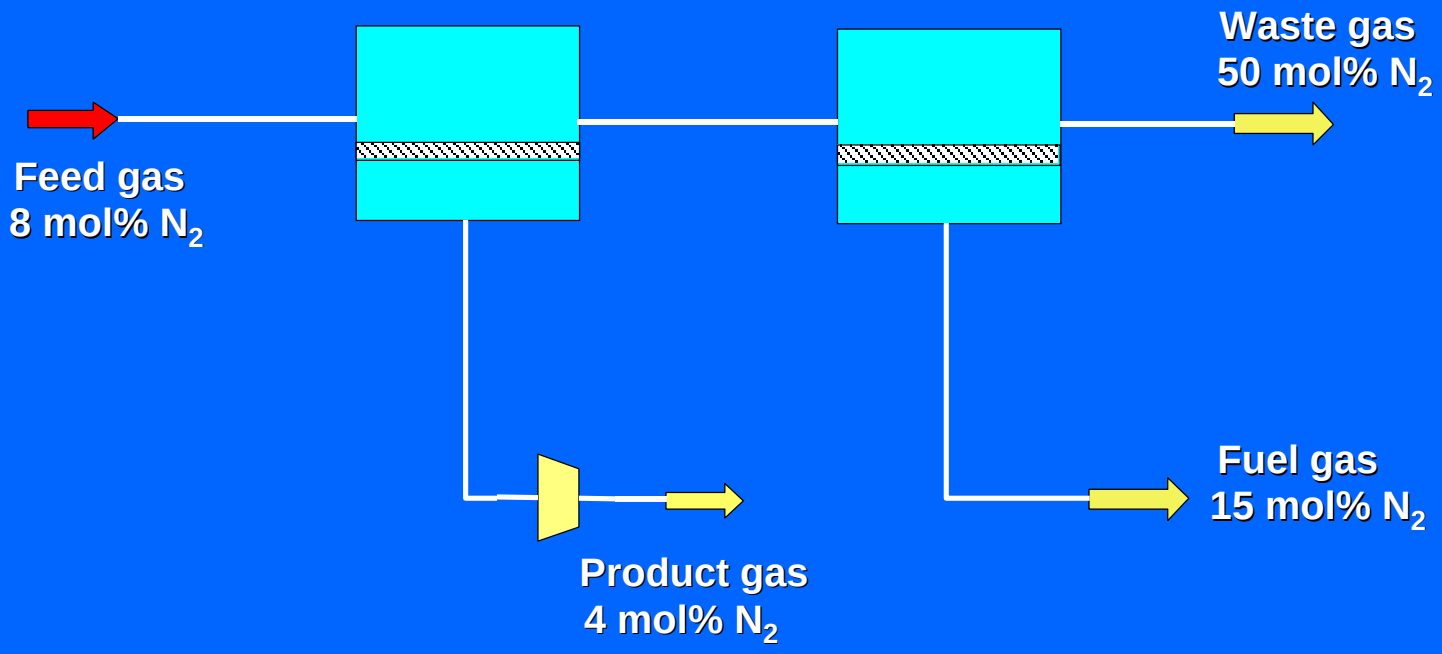
Case 1 : Inlet N_2 Content = 8 mol%



Two step process produces pipeline quality gas and fuel gas for process use.

Product gas compressor may be required to boost pressure to pipeline pressure.

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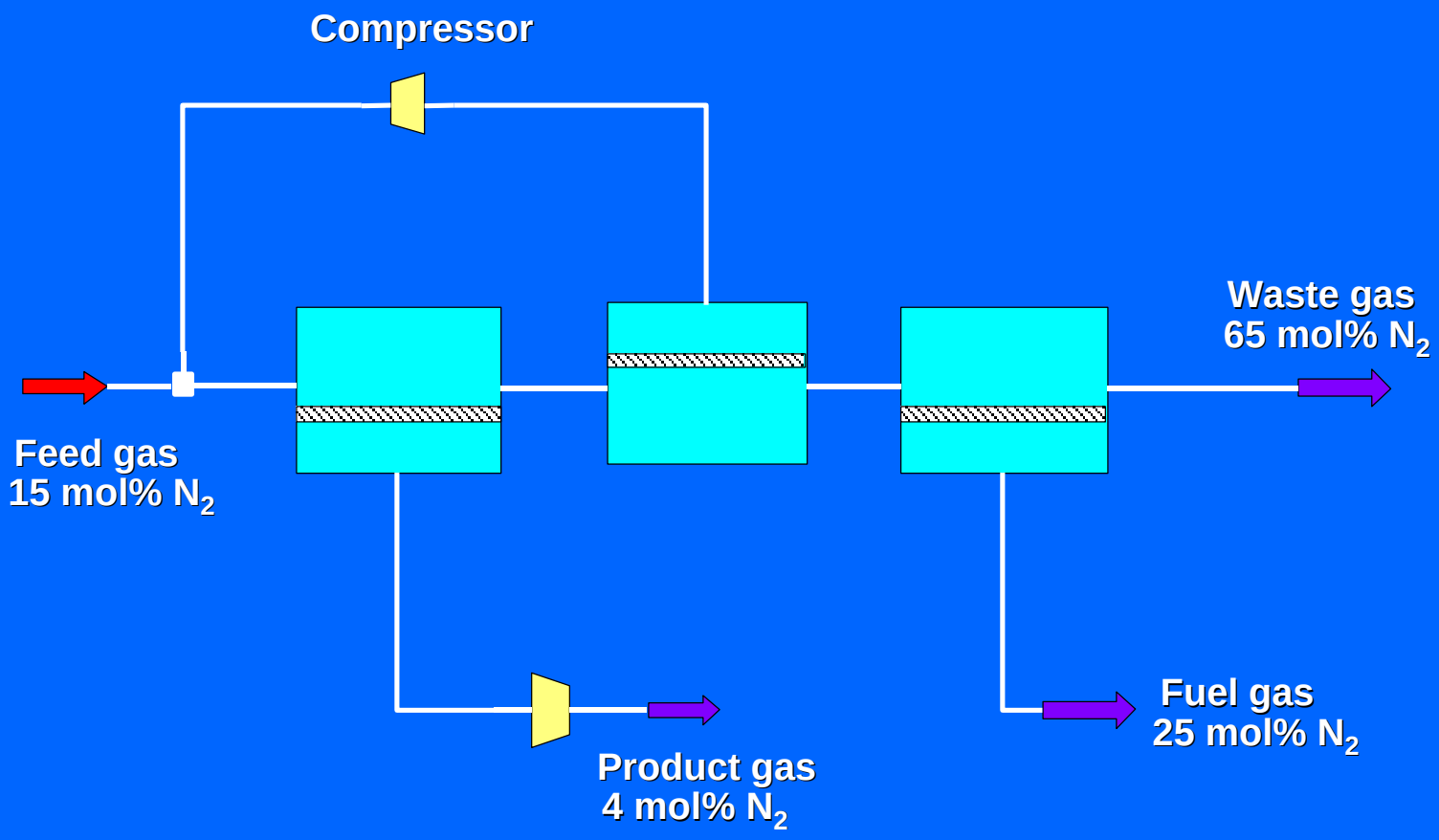
Case 2 : Inlet N_2 Content = 15 mol%



Economic Analysis

Parameter	Configuration 1	Configuration 2
Process Characteristics		
N_2 in feed (%)	8	15
Feed flow rate (MMSCFD)	10	10
N_2 in product gas	4	4
Methane recovery (%)	86	86
Methane in fuel gas (%)	87	75
Methane in waste gas (%)	50	35
Product gas flow rate (MMSCFD)	8.2	7.6
Power Requirements		
Power required (Hp)	750	2,000
Capital and Operating Costs		
Equipment cost ($000)	1,800	3,500
Processing cost ($/1000 scf)	0.27	0.56

- Processing Costs about 0.25 to 0.5 $/MCF are very favorable
- Membrane system are flexible and can be used for various sites and inlet gas compositions
- Ideal for remote continuous operation without operator attention
- Well suited for low flow rate applications

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Similar Applications – Fuel Gas Conditioning for Gas Engines and Turbines

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

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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**
- **Large turndown ratio**
- **Low maintenance**
- **Lower capital and operating costs**

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Summary

Other applications in the Oil & Gas Industries for MTR's Reverse-Selective membranes

Gas: Fuel gas conditioning, NG dewpointing, NGL Recovery, Natural Gas Dehydration.

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

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