COMPACT MEMBRANE SYSTEMS

Olefins Paraffin Separations
Optiperm™ Facilitated Transport Membranes for Industrial Separations
What we’ll cover today

- Intro to CMS
- Optiperm™ Platform
- Olefins Separations
- Results
- How to get started
- Q&A
Membranes have the potential to change chemical separations

“Purification of propene and ethene alone accounts for 0.3% of global energy use, roughly equivalent to Singapore's annual energy consumption.”
Who is CMS: solution oriented with years of experience

Reliability

Durability

Flexibility

Scalability
Optiperm™ Technology for Olefin-Paraffin Separation

- Ethylene
- Propylene
- Butylene

OLEFINs
Petrochemical raw material

CRUDE OIL
NGL’s

PARAFFINS
Fuels

- Ethane
- Propane
- Butane
Enhance olefin recovery and utilization

- Fugitive Streams
- De-bottlenecking
- Reactor Purge Lines
- Column Expansion
- Specialty Chemical
- ...and more
Step Change technology to unlock significant potential value

High capex, energy intensive

Fixed, inflexible

Low Cost

Modular, flexible
CMS proprietary technology delivers high value chemical separation

**Patented Membrane Chemistry + Design**
Chemistry does the work, not pressure and size

**Modular Design**
Compact and modular, not large and bespoke

**Simplified System Integration**
Lower OpEx, CapEx requirement
Successful pilot in the field

Goals

• Full system design with 2 stages
• Commercial scale membrane cartridges
• Produce high purity propane and propylene simultaneously
• Validate membrane predictive models and integrate into control scheme

Takeaways

• System operating as designed
• Membranes stable for 2000+ hours
• Hitting propane and propylene specs simultaneously
• Demo unit has hit all milestones to date
Real scale implications

✓ Commercial sized membranes
✓ Control system design
✓ Representative of commercial application
Membranes delivering stable performance

STAGE 1

- Varying operating conditions
  - 110 to 165 psig
  - 100 to 110 F
  - Feed 72 to 81% C3=
- >1500 days in operation excluding s/d's – change to hours
Stable membrane performance

**STAGE 2**

- Varying operating conditions
  - 140 to 185 psig
  - 100-110 F
  - Feed 72 to 81 %C3=
- >2000 days in operation excluding s/d’s
Achieving purity targets during testing

- Testing to define operating window
- Simultaneously Producing CGP and HD5
Where is Optiperm™ Technology Valuable?

- PP Reactor Purge
- C₃ Alkylation
- C₃ Off Gas Reactor
- C₃ Splitter Debottleneck
- Propane/Propylene Upgrade
- C₃ from Refinery Fuel Gas
- C₃ Splitter Replacement
- C₄ Alkylation
- C₄ from Refinery Fuel Gas
- C₄ Alkylation
- C₂ Splitter Debottleneck
- PE, EO and MEG Reactor Purge
- C₂ Off Gas
- C₂ Splitter Debottleneck
- Methane to Ethylene
- Specialty Chemical
- Specialty Chemical
- Specialty Chemical
- Specialty Chemical
- C₂ from Refinery Fuel Gas
- C₂ Splitter Debottleneck
- PE, EO and MEG Reactor Purge
- C₂ Off Gas
- Liquid phase extraction

Existing customer requests

Small (<$5M)  Medium ($5-$40M)  Large (>=$40M)
Bolt-on in existing plants and de-bottleneck to increase revenue, capacity, throughput, reduce emissions.

Case 1: C3 splitter
- Membrane sales: $3.8 Million
- IRR: 70%
- Payback: 17 months

Case 2: PP purge line
- Membrane sales: $3 Million
- IRR: 150%
- Payback: 9 months

Excellent customer economics.
## Kick start your project today

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<th>Identify your stream</th>
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<td>Size and characterize your system (CAPEX, OPEX)</td>
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<td>Reserve your system in the queue</td>
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<td>Commission build</td>
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THANK YOU

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