Caplus®
Specialty Amine Technology for Acid Gas Removal
Caplus® is Evonik’s next generation solvent for gas treating applications

Caplus® is a proprietary solvent allowing plant operators to push forward the performance of existing gas treating units.

Increased treating capacity
Increased energy savings
Currently used absorbents for acid gas removal may cause serious issues for customers.

Feedstock

- Biomass
  - Fermentation
  - Biogas upgrading
  - Pure biomethane

- Raw natural gas (well)
  - Oil – Condensate separation
  - Acid gas removal
  - Demethanizing
  - Fractionation
  - Methane
  - NGLs

- Methane, hydrocarbons
  - Reforming
  - CO₂ removal
  - H₂ + CO
  - Fischer Tropsch
  - Ammonia reactor
  - Liquid fuels
  - Ammonia
  - Other synthesis
  - Other chemicals
Currently used absorbents for acid gas removal may cause serious issues for customers

<table>
<thead>
<tr>
<th>State of the art solution</th>
<th>Plant operation and gas treatment</th>
<th>Issues for plant operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDEA + Piperazine</td>
<td></td>
<td>Capacity limitations</td>
</tr>
<tr>
<td>Sulfinol</td>
<td></td>
<td>Foaming</td>
</tr>
<tr>
<td>Aminoethoxy-Ethanol (AEE)</td>
<td></td>
<td>Corrosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Degradation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy intensive</td>
</tr>
</tbody>
</table>

- Lower plant availability
- High maintenance costs/efforts
- High OPEX
Evonik’s absorbent is able to overcome the existing industry issues

Characteristics of Evonik’s superior absorbent Caplus®:

- Based on Evonik’s 20 years of production experience in specialty amines
- More than one amine group per molecule
- Unique & optimized molecular structure
- Aqueous solution like state-of-the-art amines
- Drop-in at existing AGRU without process modifications

Performance Benefits of Evonik’s absorbent

- Eliminate capacity bottlenecks
- Reduce your life cycle cost
- Reduce regeneration energy
- Minimize solvent degradation
- Increased operational flexibility

Caplus® is not based on MDEA
Caplus® offers capacity & flexibility. Increase the gas throughput or better cope with an increased acid gas content in feed gas of ageing wells.

**CO2 Cyclic Capacity**

- $P_{CO2} = 1\text{ bar (40 °C)} \& 0.1\text{ bar (120 °C)}$
- 40 wt% promoted MDEA
- 40 wt% Caplus®

**H2S Cyclic Capacity**

- $P_{H2S} = 0.1\text{ bar (40 °C)} \& 0.01\text{ bar (120 °C)}$
- 40 wt% promoted MDEA
- 40 wt% Caplus®
Caplus® ensures reliable operation due to low foaming and reduced corrosion compared to MDEA/PZ

**Low Foaming**

<table>
<thead>
<tr>
<th>Foam Volume (%)</th>
<th>40 wt% promoted MDEA</th>
<th>40 wt% Caplus®</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>20%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>40%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>60%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>80%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>100%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
</tbody>
</table>

7 vol% CO₂ in CH₄ @ 25 °C

**Low Corrosion**

<table>
<thead>
<tr>
<th>Corrosion Rate with CO₂ (%)</th>
<th>40 wt% promoted MDEA</th>
<th>40 wt% Caplus®</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>20%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>40%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>60%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>80%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
<tr>
<td>100%</td>
<td>Grey</td>
<td>Magenta</td>
</tr>
</tbody>
</table>

Coupon test: Carbon steel type 1.0425; Pₐₜₜ = 3.85 bar; 15 days @ 70 °C
Commercial plant with Caplus®: Capacity Increase and/or Energy Savings together with a higher Chemical Stability lead to reduced amine life cycle costs and thus beneficial economics.

- **Capacity Increase**
  - Amine Flow Rate
  - MDEA/Pz
  - CAPLUS

- **Chemical Stability**
  - Heat-Stable Salts [mol]

- **Energy Savings**
  - Specific Regeneration Energy
  - MDEA/Pz
  - CAPLUS

- **Beneficial Economies**
  - Reliable Operation
  - Significantly less Degradation
  - Savings in Regeneration Energy
  - Capacity Increase Potential

  = Beneficial Amine Life Cycle Costs
  = Lower Specific Gas Treating Costs
Caplus® superior performance was already proven at commercial customer plant and next steps are prepared

**Development status and outlook**

- Evonik’s absorbent is offering a strong value proposition

- Superior performance has been proven at commercial customer plant

- Further technology introduction is being prepared focusing on the pipeline natural gas market