New UOP Platforming™ Catalysts Commercialization Update

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Flexible Operations: highest activity, stability and yields over cycle - commercialized in 2010

Low Density

R-500
Flexible Operations: highest activity, stability and yields over cycle
- commercialized in 2010

R-98
Highest yields and lowest cost
- 35+ units loaded since 2005

R-86
Higher yields and lower cost
- 100+ units currently loaded since 2001

R-56
Maximum stability
## UOP Catalyst Performance Comparison

<table>
<thead>
<tr>
<th></th>
<th>R-56</th>
<th>R-86</th>
<th>R-98</th>
<th>R-500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C₅⁺ Yield (SOR)</strong></td>
<td>Base -</td>
<td>Base</td>
<td>Base +</td>
<td>Base +</td>
</tr>
<tr>
<td><strong>C₅⁺ Yield (Over Cycle)</strong></td>
<td>Base -</td>
<td>Base</td>
<td>Base +</td>
<td>Base ++</td>
</tr>
<tr>
<td><strong>H₂ Yield (SOR)</strong></td>
<td>Base -</td>
<td>Base</td>
<td>Base +</td>
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</tr>
<tr>
<td><strong>H₂ Yield (Over Cycle)</strong></td>
<td>Base -</td>
<td>Base</td>
<td>Base +</td>
<td>Base ++</td>
</tr>
<tr>
<td><strong>Start Of Run (SOR)</strong></td>
<td>Base - 5</td>
<td>Base</td>
<td>Base - 3</td>
<td>Base - 12</td>
</tr>
<tr>
<td><strong>Temperature, °F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stability, Relative</strong></td>
<td>Base</td>
<td>Base</td>
<td>Base</td>
<td>Base ++</td>
</tr>
</tbody>
</table>

*R-500 has 12°F activity & increased stability advantage vs. R-86*
R-500 Breakthrough Performance

**R-500 Catalyst**

- Addresses needs for increased flexibility
- Highest activity and stability of any commercially available catalyst
- Superior stability leads to increased average yield per cycle
- Several ways to take advantage of improved yield stability

R-500 adds significant value over any commercially available fixed-bed reforming catalyst
R-500 Commercialization Update

**Average Octane – Barrels Reformate per Cycle**

- **UOP R-56**: ~7 months
- **Competitor A**: ~2.5 months
- **UOP R-500**: ~9 months

**~70% of full 1st cycle (projected 18 MM Octane barrels)**

*R-500 improved productivity and minimized downtime*
## R-500 Commercialization Update

### Operational Data/ Comments

<table>
<thead>
<tr>
<th></th>
<th>EOR Non UOP</th>
<th>SOR R-500</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₅ + yield</td>
<td>Base</td>
<td>3-5 % increase</td>
<td>Increase</td>
</tr>
<tr>
<td>H₂ + yield</td>
<td>Base</td>
<td>2-4 % increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Hydrogen plant load</td>
<td>Base</td>
<td>2-4 % less</td>
<td>Decrease</td>
</tr>
<tr>
<td>SOR WAIT</td>
<td>Base</td>
<td>- 10 °F</td>
<td>Decrease</td>
</tr>
<tr>
<td>Stability</td>
<td>20°F greater than SOR temp., rapid yield decline observed</td>
<td>30°F greater than SOR temp., stable yields</td>
<td>Increase</td>
</tr>
<tr>
<td>Chloride injection</td>
<td>Base</td>
<td>50% less</td>
<td>Decrease</td>
</tr>
</tbody>
</table>

- Cycle length: 9 month run to date; Power outages, NHDS sulfur upset, extended high RON runs
- Reduced load on Operators

*Multiple benefits were achieved with R-500 catalyst*
**Promoted Catalysts**

- **R-284 R-254**
  - Highest yields, high stability, low coke, good activity
  - R-254 commercialized in 2010

- **R-264**
  - High yield, highest activity
  - 60+ units loaded since 2004

- **R-274**
  - Highest yield with lower activity
  - 15+ units loaded since 2002

- **R-234**
  - High yields, high stability, low coke, excellent activity
  - 100+ units loaded since 2000

- **R-134**
  - Similar to R-234 with higher coke
  - 140+ units loaded since 1993

**Market Drivers**

- Long catalyst life, excellent stability, high chloride retention, low fines make and low coke make
UOP Continues to Innovate New Products

New low density R-254 and high density R-284 catalysts

- New catalysts have modified acid function to improve selectivity of cyclization vs. cracking but with less activity loss
- Acidity modification of alumina bases with addition of promoter
- Higher activity than R-274 catalyst while maximizing yields

\[ C_1 + C_2 \text{ Cracked Products} \]

\[ M \quad A \quad M \quad A \quad M \quad A \]

M = Metal
A = Acid

Improve selectivity of cyclization over cracking Rxs.
CCR Catalysts for Achieving Higher Octane Barrels

Yield-Activity Deltas for UOP CCR Catalysts

Low Density
- R-234: low density for reduced fill cost
- R-254: best yields available with good activity

High Density
- R-264: best activity available, can maximize throughput if heater limited
- R-284: best yields with good activity

Work with UOP to choose the right CCR Platforming catalyst to maximize octane barrel production, H2 and aromatics
R-254 Commercial Experience

**H₂ YIELD and RONC**

- **H₂ Yield** vs. **RONC**
- Data points for H₂ Yield SCF/bbl and Reformate RONC over the period from 21-Jan to 1-May.

**C₅+ YIELD and RONC**

- **C₅+ Yield, wt%** vs. **RONC**
- Data points for C₅+ Yield and Reformate RONC over the period from 21-Jan to 1-May.

**WAIT and RONC**

- **WAIT °F** vs. **RONC**
- Data points for WAIT Deg F and Reformate RONC over the period from 21-Jan to 1-May.

<table>
<thead>
<tr>
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<th>EOR R-234</th>
<th>SOR R-254</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₅+ yield</td>
<td>75-76 lv%</td>
<td>76-77 lv%</td>
<td>~1 lv% increase</td>
</tr>
<tr>
<td>H₂ +yield</td>
<td>~1100 scf/b</td>
<td>1300-1350 scf/b</td>
<td>~20% increase</td>
</tr>
<tr>
<td>WAIT/WABT</td>
<td>Base</td>
<td>+0/-10</td>
<td>Decrease*</td>
</tr>
<tr>
<td>Coke</td>
<td>Base</td>
<td>Directionally Lower</td>
<td>Decrease</td>
</tr>
<tr>
<td>Chloride injection</td>
<td>Base</td>
<td>20-50% less</td>
<td>Decrease</td>
</tr>
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R-254 met all of the customers expectations with a pay back of less than 1 year
New High Yield R-284 Catalyst

R-284 Catalyst

- Aromatics and motor fuels catalyst
- High yields, low coke
- Higher activity vs. R-274 catalyst
- High density can help maximize throughput by alleviating pinning constraints
- Modified alumina base with promoter
- Builds on knowledge and experience of the R-264 and R-274 catalysts

New R-284 catalyst provides high yields and flexibility
R-284 has higher A8 and A9 yields vs. R-264 HY

The R-284 increase in Total Aromatics of 0.5 wt% represents:
0.9% A8 increase (24.1 to 24.3% in above example)
1.7% A9 increase (14.8 to 15.1% in above example)

For a typical 1000KMTA CCR Platformer that would mean an additional 2KMTA A8’s for px production and an additional 2.5KMTA of A9’s that can be converted into A8’s and Benzene in the Tatoray unit.
UOP Can Help Improve Your Profitability

- Extensive, proven reforming catalyst portfolio that meets a variety of needs
- New R-500 and R-254 catalysts combines selectivity and activity improvements to provide additional flexibility
- R-500 has superior stability for longer cycles or more octane barrels over cycle
- R-500 has already been sold to three refiners and has been successfully loaded in two units achieving and exceeding customer’s expectations
- R-254 low-density catalyst provides high C$_5^+$ and H$_2$ yields; value for high octane operation and reduced severity
- R-254 has been sold to 6 refiners and has successfully loaded in 4 units
- UOP can apply a multifaceted solution to help improve your operations

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Q&A