Independent Catalyst Test Report 2015

Pushing the limits of FCC gasoline desulfurization
FCC gasoline desulfurization

- Goal: desulfurize FCC gasoline with minimum octane loss
- Uses conventional naphtha hydrotreating
- Uses selective catalysts to minimize olefin saturation
Commercial status

- Got off the ground in 1999
- There are now 300 units in the world
- Most are Scanfining (ExxonMobil) or Prime G (Axens) units
- Revamps and new builds are ongoing
FCC gasoline desulfurization catalysts are designed for *olefin retention selectivity*

- Excerpt from ExxonMobil presentation
- Shows ExxonMobil pilot plant data - *olefin retention selectivity*
Independent catalyst test report 2015 (ICT 2015)

- Side-by-side pilot plant tests of competitive catalysts
- Catalysts are ranked on activity and selectivity
- Includes competitive analysis
- Includes new insights on the process
ICT 2015 - desulfurization activity

Hoekstra 10-20N catalyst test

Cold temp
Warm temp
Hot temp
Other experiments

Sulfur ppm

Days
ICT 2015 - olefin retention selectivity

- Green and white data points are from ICT 2015 tests of competitive catalysts
- Trendlines are XOM pilot plant data for RT-225 and RT-235

Note: This chart shows 4 of 20 data points from ICT Report 2015
ICT 2015 Catalyst ranking grid

<table>
<thead>
<tr>
<th>Delta Activity</th>
<th>Delta Selectivity</th>
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<tbody>
<tr>
<td></td>
<td>Base selectivity</td>
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<tr>
<td></td>
<td>-20°F</td>
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<tr>
<td></td>
<td>-10°F</td>
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<td>0°F</td>
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<td>+10°F</td>
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<td>+20°F</td>
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<td>+30°F</td>
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Test catalysts are placed in this grid
Pushing the limits

- Studying the detailed chemistry of the process
- Pushing severity to make ultra low sulfur gasoline
Pushing the limits

Reactivity of compound groups
ICT 2015 – olefins by carbon number

Hoekstra 10-20N catalyst test

olefins by carbon number

wt% olefins

Carbon number

Hoekstra Trading LLC
ICT 2015 - olefin selectivity by compound group

C5 olefins

C9 olefins

Wt%
Pushing the limits
Selectivity by individual compound
ICT 2015 - olefin selectivity by individual compound

- 2-methyl-2-butene
- A C10 olefin

Graphs show the relationship between sulfur content (ppm) and weight percentage (%) for the two compounds.
Pushing the limits

Selectivity for other hydrocarbon types
ICT 2015 - isoparaffin selectivity

Hoekstra 10-20N catalyst test

Normal operating window

temperature increasing

Isoparaffins, wt%

Product sulfur, ppm

1 10 100
Pushing the limits

Increasing severity to make ultra-low-sulfur gasoline
ICT 2015 – octane retention selectivity

- Hoekstra 10-20N catalyst test
- Normal operating window
- Increasing severity
- Product sulfur, ppm
- RON Octane
Other reactions start happening as you go out here.
ICT 2015 – octane retention selectivity

Hoekstra 10-20N catalyst test

Normal operating window

It is possible to INCREASE octane while going deeper in desulfurization

Increasing severity

Product sulfur, ppm

RON Octane
Independent catalyst test report 2015

- Competitive catalysts have been tested
- They are ranked on desulfurization activity
- They are ranked on olefin retention selectivity
- Large improvements in desulfurization/octane performance are possible at deep desulfurization
- The report is available to anyone from Hoekstra Trading
Thanks for your attention!

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