

Selective Hydrogenation Catalysts Selection & Performance

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- **Hydrogenation Catalysis Overview**
- **Catalyst Strategy applied to:**
 - **C₃ Selective Hydrogenation**
 - **C₄ Hydrogenations**
 - **Pygas Hydrogenations**
- **Commercial Experience**



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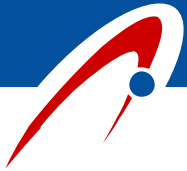


Axens' Hydrogenation Catalyst Trends

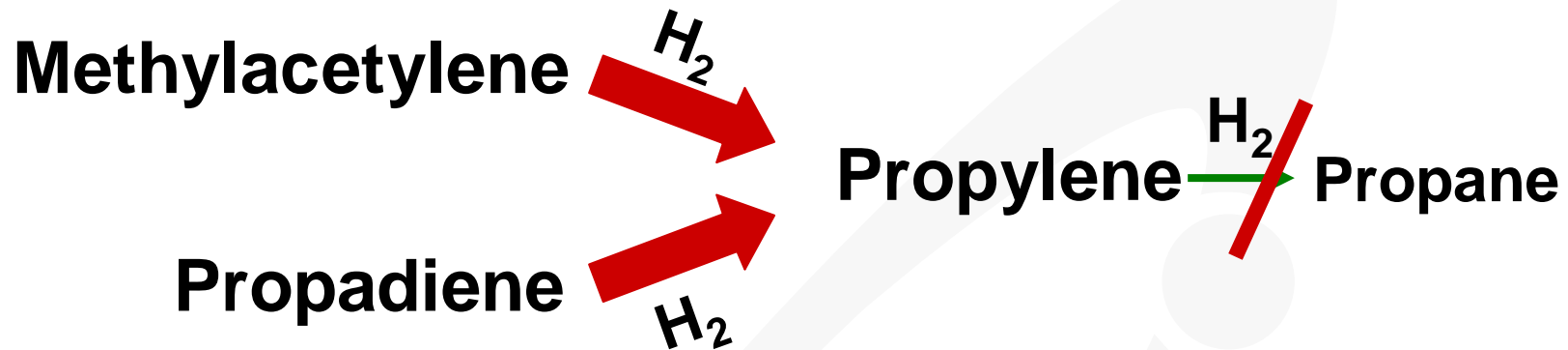
- **Pd and Ni Optimum Activity/Selectivity**
- **C₃ and C₄ Cuts**
 - **Pd-Based Catalysts - Still The Best**
High selectivity & activity - low oligomerization
 - **Pd-Based Bimetallic Catalysts**
Higher performance
- **C₅+ (Pygas) Cuts**
 - **High Activity: Pd-Based Catalysts**
 - **High Tolerance to Impurities/Low Cost: Ni catalysts**

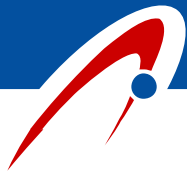


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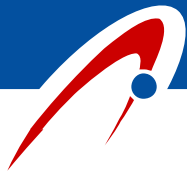


Steam Cracker C₃ Hydrogenation





- **LD-265 low cost option**
- **LD-273 high performance**
- **LD-273 cost control: low palladium content**
- **High tolerance to impurities**
- **Propylene yield improvement**
 - **1% increase in C₃= yield at 10 ppm MAPD at the outlet**
 - **Commercial experience at 1 ppm MAPD at the outlet**
- **Long Cycles (Typically > 3 Years)**

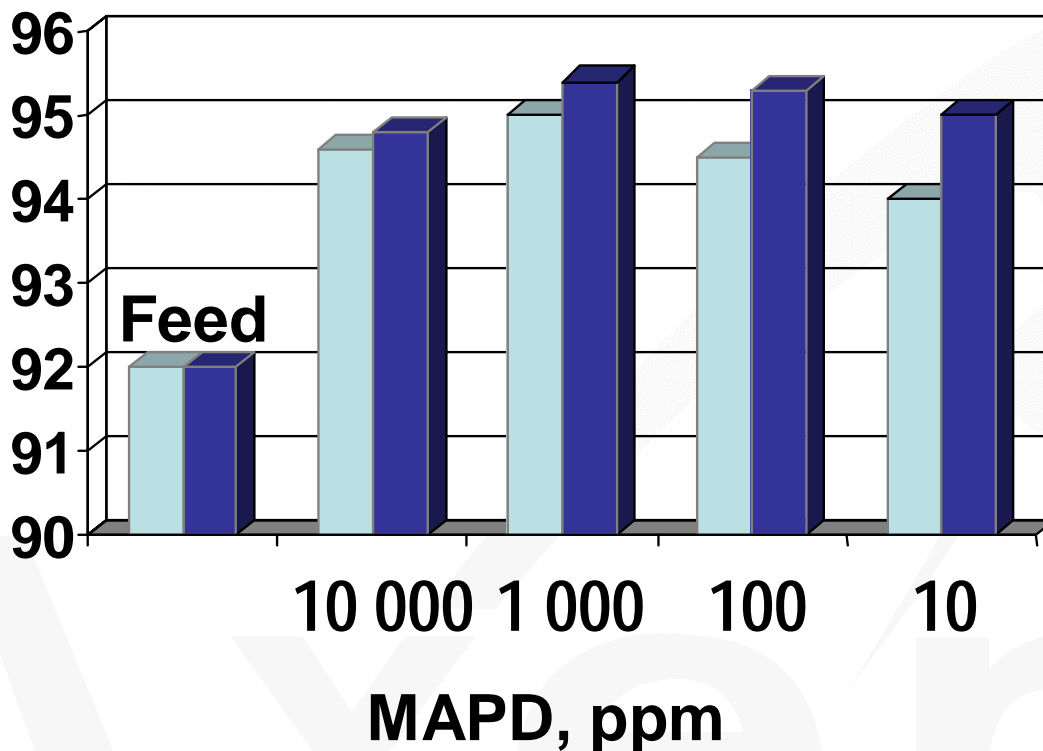


Yield Improvement with the Right Catalyst

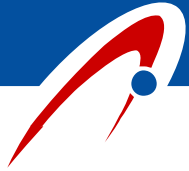
Commercial Data

Propylene Content,

wt%



Conventional Catalyst
LD-273

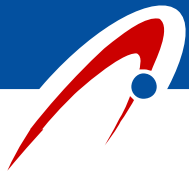


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Steam Cracker C₄ Processing Options

- **Butadiene Production**
- **Recycle to Furnaces or LPG Production**
 - **Olefins Minimization**
- **Butenes Production**
 - **Maximum 1-Butene**
 - **Maximum 2-Butenes**
- **Pure Isobutylene Production**



LD Series Portfolio for C4 Hydrogenation

**Acetylenes SHU
LD 277**

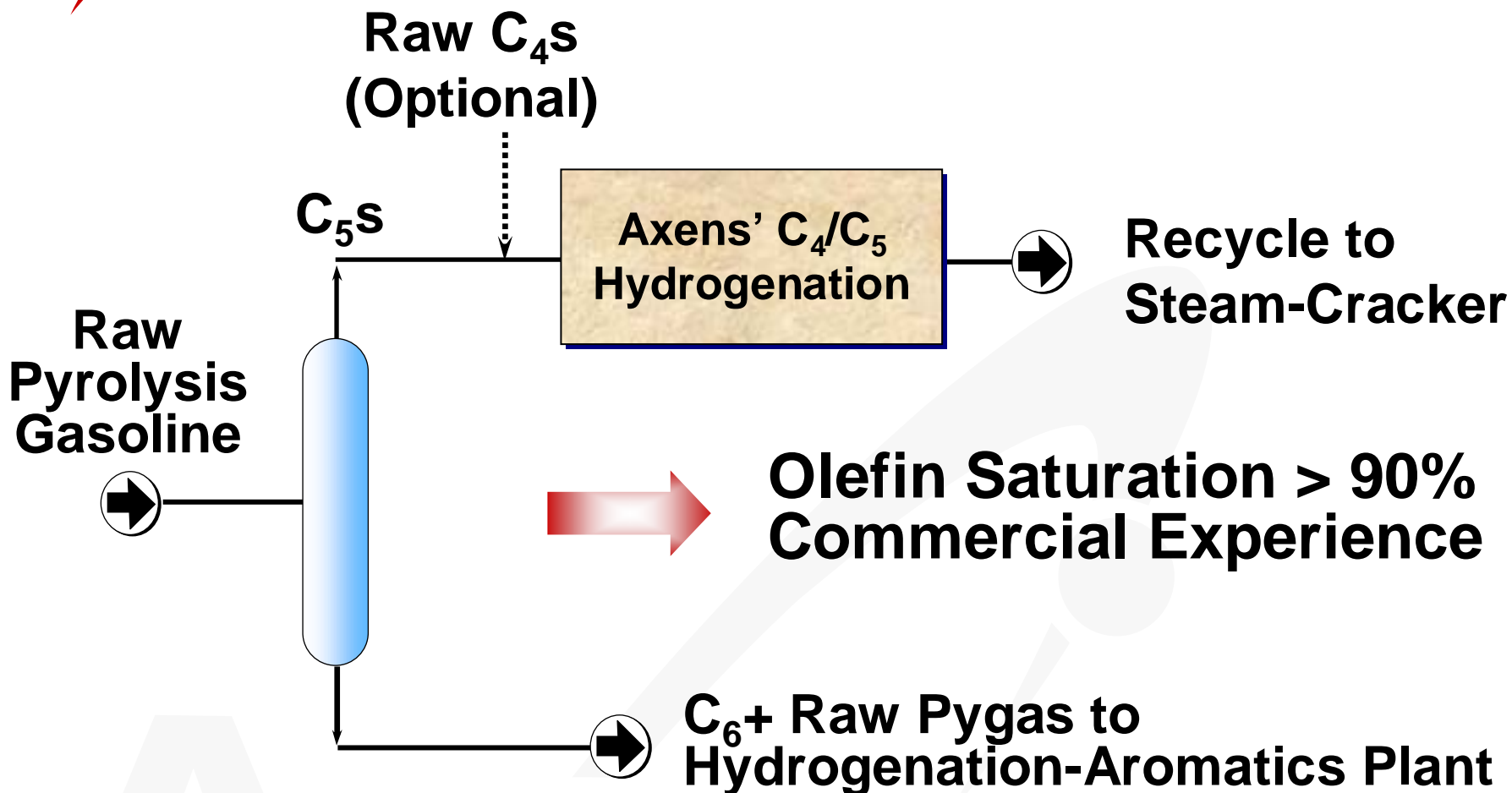
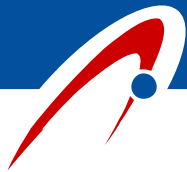
**Total
Hydrogenation
LD 265, LD 365**

**BD Selective
Hydrogenation
LD 265**

**Max.
1-Butene
LD 271**

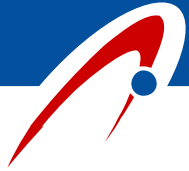
**Max.
2-Butene
LD 267R**

C₄/C₅ Olefins Deep Hydrogenation

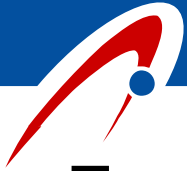




- **LD 271 High Performance**
- **Bimetallic**
- **Cost control: low palladium content**
- **Moderate tolerance to Impurities**
- **Butene-1 yield improvement**
 - **Increase in B1= yield below 50 ppm BD**
 - **Commercial experience down to 1 ppm BD (50% of BD to B1)**
- **Long cycles (typically > 3 years)**



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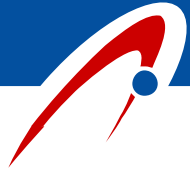


Typical composition of C₅ - 200 °C Pyrolysis Gasoline

	wt %
Paraffins	8 – 12
Aromatics	58 – 62
Olefins	8 – 10
Diolefins	18 – 22
Total sulfur	50 - 300 ppm

- ***High potential for BTX (benzene, toluene and xylenes) Upgrading***
- ***Potential for the gasoline pool (depending on olefin balance)***
- ***Sulfur removal required in all cases***
- ***Very unstable raw material – SHU required***





Catalyst	Metal	Relative Activity per Volume	Relative LHSV	Cycle Length, Years*
LD 241	Ni	1	1	0.5
LD 341	Ni	2	1.5 - 2	0.8 - 1.5
LD 265	Pd	2	1.5 - 2	0.8 - 1.5
LD 365	Pd	3	2.5 - 3	1 - 2

*** for Full Range C₅ - 200°C Pyrolysis Gasoline**



Case	Previous Catalyst	New Catalyst
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Unit Revamp / Catalyst Change

Up to 150% Capacity Increase	LD 265	LD 365
	LD 241	LD 341
New Feed with Contaminants	LD 265	LD 341
	LD 241	LD 341

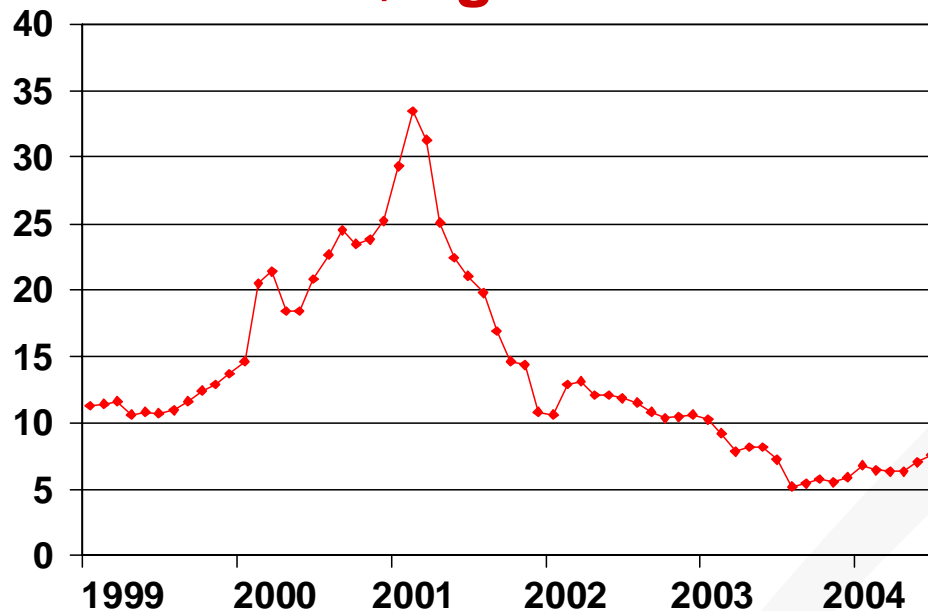
Grassroots unit

Uncontaminated Feed	LD 365-341
Contaminated Feed	LD 341



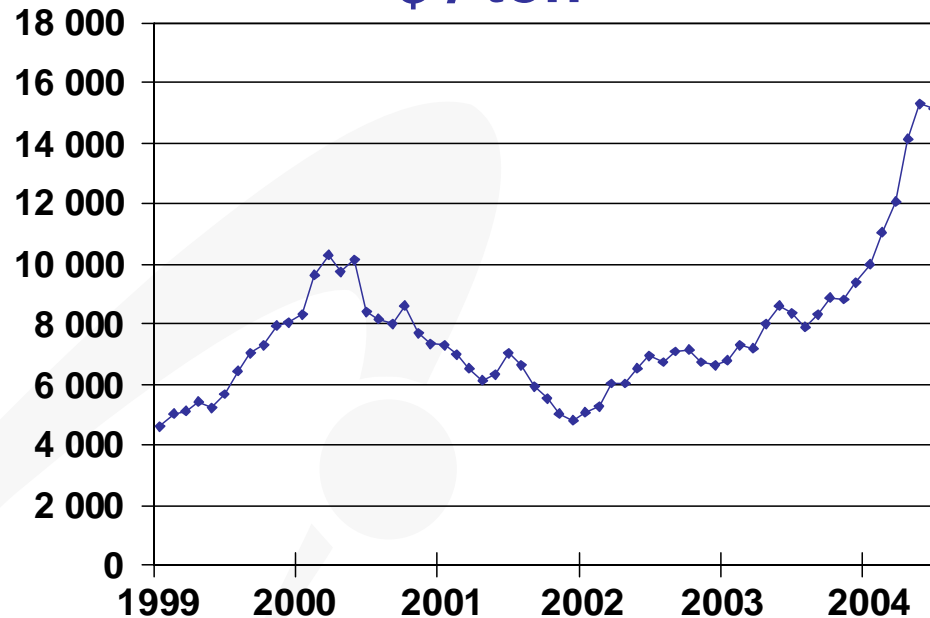
Palladium & Nickel Prices

London Palladium Price, \$/ gram



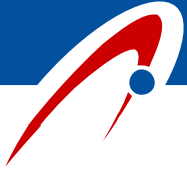
Source: Kitco

London Nickel Price, \$/ ton



Source: London Metal Exchange

Pd versus Ni - Technical & Commercial Choice



**First Catalyst:
(LD 145)**

**Dedicated to olefins hydrogenation
Avoids bed plugging and pressure
drop build-up**

Second Catalyst:



**Highly active and selective
Low product sulfur and olefins
No aromatics loss**

Catalyst	Metal	Relative Volume Activity	Cycle Length, Years
HR 306	CoMo	1	3
HR 406	CoMo	1.5	4



SHU Revamping Industrial Experience

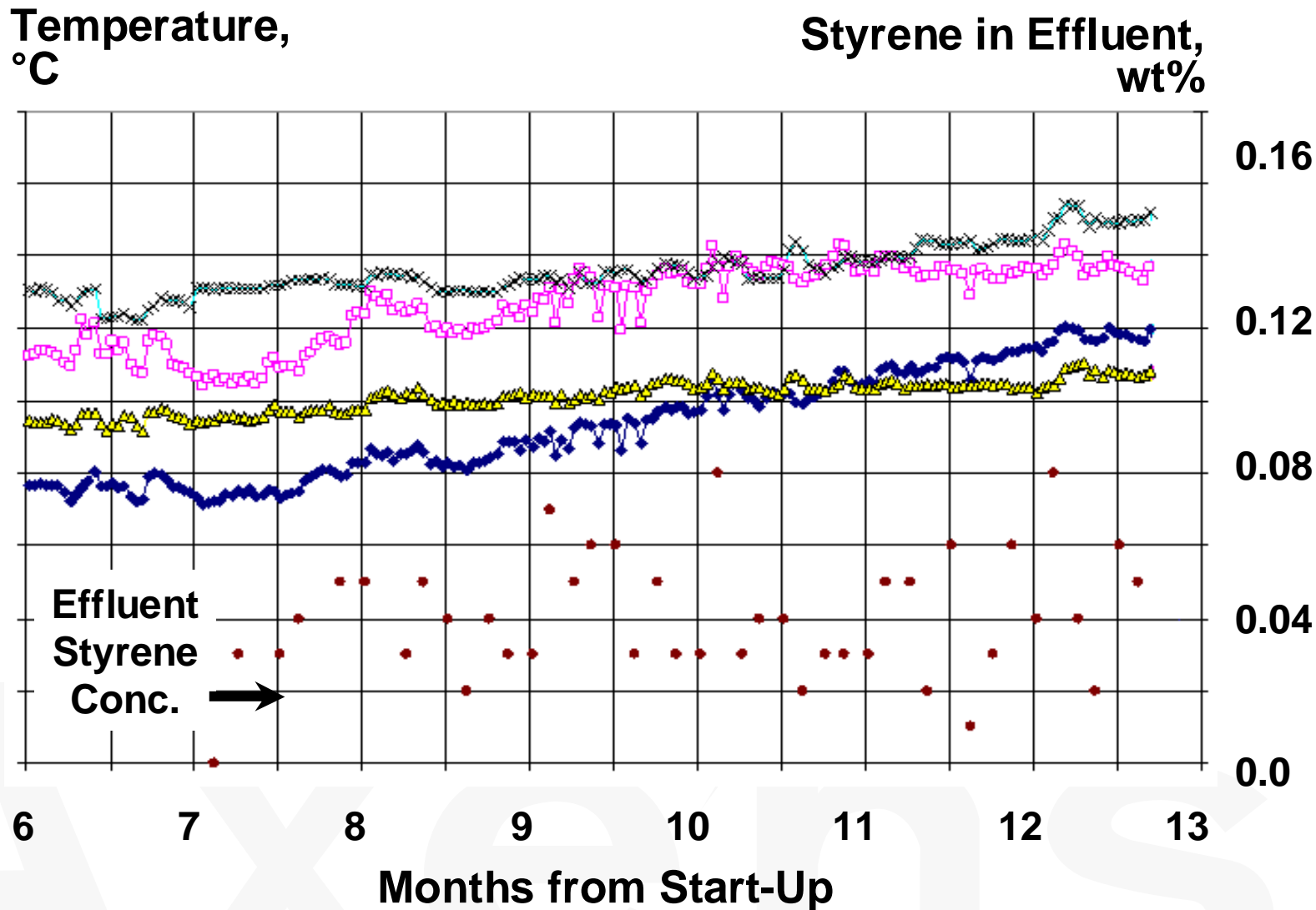
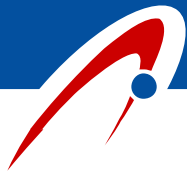
Pygas SHU Revamp + High Activity LD 365 Catalyst

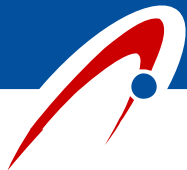
	SHU Reactor Inlet Temp.	Cycle Length, years
Before 1988	Base	1
1988-1998 LD 265	Base – 50 %	2
1998+ Rev. + LD 365	Base – 70 %	4



***Effectiveness of Revamping
Severe Specifications
Extremely Long Cycles***

Pygas SHU Ultra High Severity Operation LD 365 for Styrene Conversion





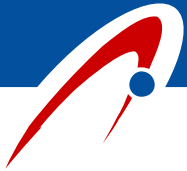
Contaminated Feedstock Replacement of Pd Cat. by LD341

Contaminated Feedstock: As (50-300 ppb), Si, Hg

	Palladium Catalyst	Axens LD 341
Styrene in Product, wt%	< 0.3	< 0.3
Cycle Length	Base	Base * 5



***Industrial Experience in Asia
Effectiveness of Cat. Replacement by LD 341
Significantly Improved Unit Reliability and
Added Economic Value***



LD Series Portfolio Summary

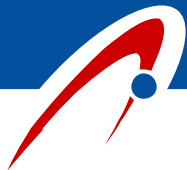
Pygas HDS
LD 145
HR 406

C₃ SHU
LD 265
LD 273

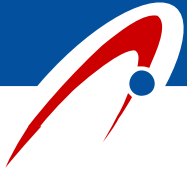
Pygas SHU
LD 265, LD 365
LD 241, LD 341

Miscellaneous
LT 279 (C₂)
LD 277 (VAC)
LD 2773 (S)

C₄ SHU
LD 265
LD 271, LD 267R



- **Balanced and Complete Product Range**
- **C₃/C₄ Cuts**
 - **Low Cost**
 - **High Performance (Selectivity, Stability)**
- **Pyrolysis Gasoline**
 - **Pd for Highest Activity**
 - **Ni for Contaminated Feedstock**
- **Continuous R&D Efforts**
- **Catalyst Strategy Complemented by Overall Approach: Toolbox Approach**



Prime Hydro Toolbox Content

- **High Performance Catalysts:**
 - **LD Series & ACT Grading Material**
- **Licensors Design Know-How**
- **Optimum Distribution: EquiFlow™**
- **Contaminant Expertise**
- **Troubleshooting Experience**
- **Advanced Process Control**



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