



Criterion's Catalysts and Processing Experience

Can Help Clients Deal with Changes in Distillate Fuel Qualities

The worldwide distillate market is forecast to be a product segment with significant growth potential due to either environmental regulation or tax incentives or both. Refiners will be challenged to make wise investments for the uncertain future that lies ahead for this segment. Will off-road products face the same severe requirements as on-road fuels? When? Will the competitive refining business or tax incentives by government trigger earlier investments than required? Certainly, this is a challenging time for refiners worldwide!

Criterion Catalysts & Technologies L.P., along with our marketing alliance team members like Shell Global Solutions and ABB Lummus Global Inc., can help provide the catalysts, process technologies, and relevant operating expertise required for the most cost effective, non-regret solutions to today's issues.

Such a team effort can help refiners answer key processing

questions. What is the best manner for the refiner to process lower quality middle distillates, especially cracked materials such as those from Cokers and FCC units that may no longer be economically blended into products facing stricter product qualities? How can the upgrading of such streams be accomplished with the minimum consumption of additional hydrogen for a given task? Can an existing reactor be

modified with just new internals and Criterion state-of-the-art catalyst[s] for the most cost effective method of meeting new regulations?

Criterion's CENTINEL technology, whether applied in "open market" or special SynCat varieties, leads the way to the type of performance required by refiners to cost effectively produce environmentally friendly improved quality middle distillate fuels. This new catalyst preparation technology substantially increases active component utilization. The key to the CENTINEL technology involves: (1) the ultimate formation of supported metal sulfides during the catalyst preparation; and (2) activation and implementation processes designed to maintain maximum dispersion of the active species through to the catalyst system being on-line in the hydroprocessing unit.

Criterion and its team members have a wealth of experience in



What's Going On...

- Clean Fuels
- Hydrotreating Catalyst
- FCC Pretreat
- Catalytic Reforming
- Lubes

Criterion Catalysts and Processing Experience - continued

Can Help Deal with Changes in Distillate Fuel Qualities

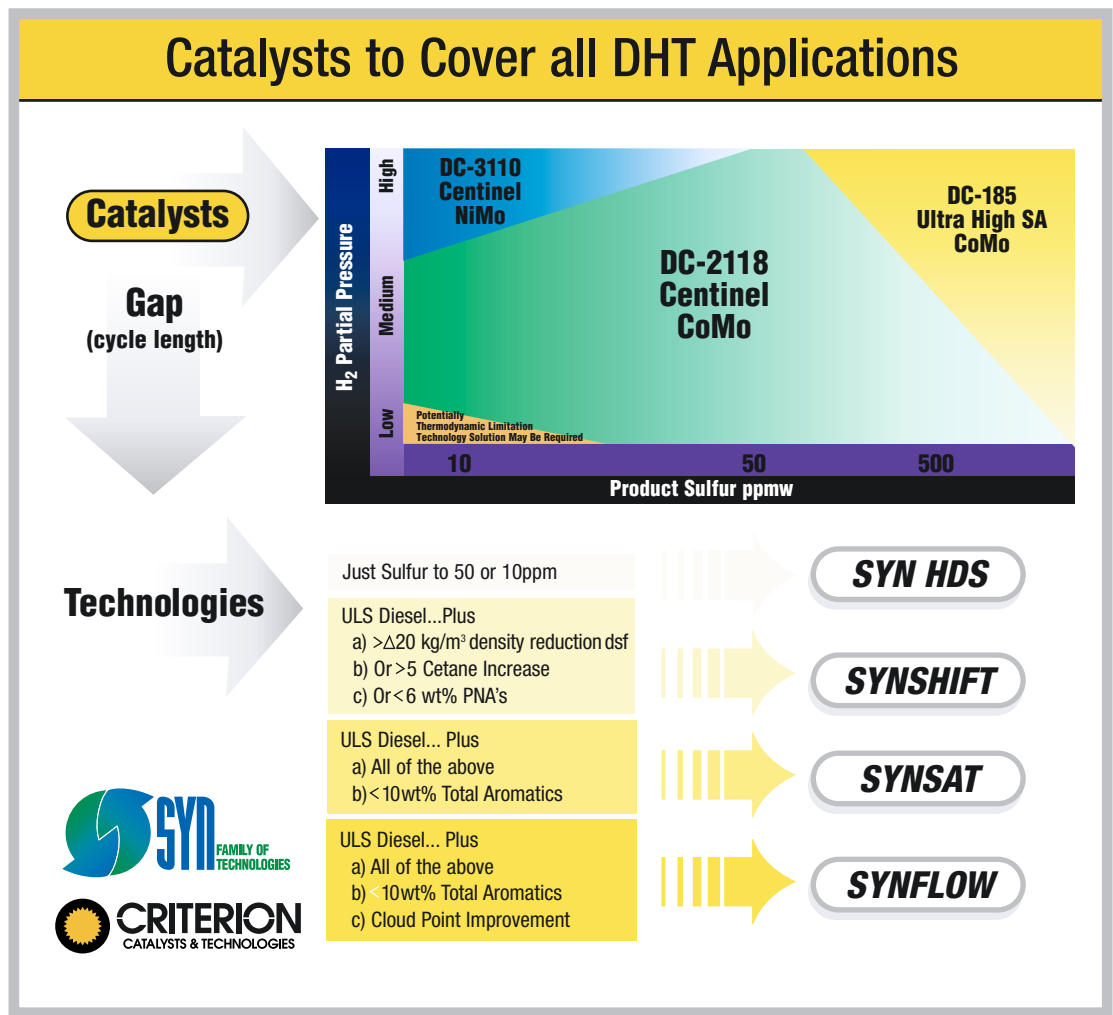
this market segment including millions of pounds of products currently in service as well as more than 10 years and more than 1 million barrels per day of processing capacity using Syn Technology which is licensed to third parties by Criterion's marketing alliance team member, ABB Lummus Global Inc.

Syn Technology type units have been producing ultra low sulfur

diesel product since the first unit started up in 1994 on feeds ranging from straight run North Sea crude derived distillate material to heavily cracked blends consisting of up to 80% Light Cycle Oil and Coker Gasoil. A key feature of the various Syn processes is that they all operate under moderate pressures thus maximizing distillate yield and cost effectiveness. There are currently nine

operating units and eight scheduled to startup over the next two years. There are four basic types of Syn Technology as illustrated in the Figure below.

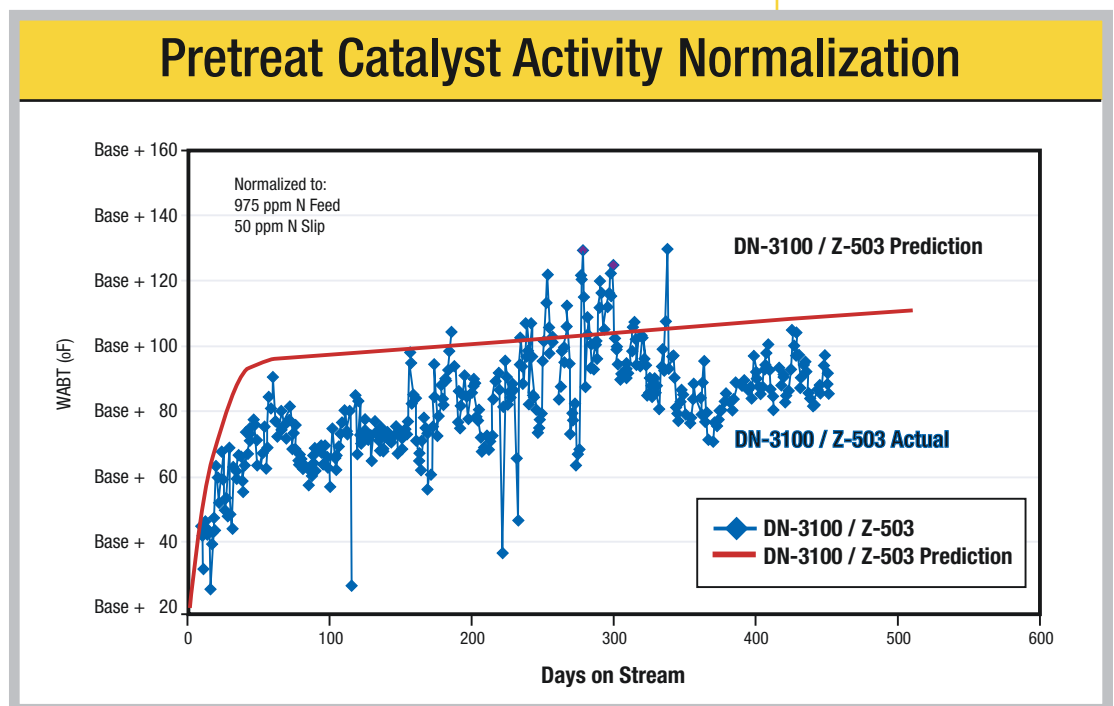
Let us tell you how we can help you with your distillate clean fuels process planning.



Criterion CENTINEL™ DN-3100

Hydrotreating Catalyst Demonstrating Excellent Commercial Performance & Ease of Start-up

Since its introduction in early 2001, Criterion CENTINEL™ DN-3100 Hydrotreating Catalyst has been installed into thirteen hydrocrackers. Performance has exceeded expectations. One of the first users of DN-3100 has been on-stream for over 450 days and continues to see DN-3100 outperform the initial predictions.

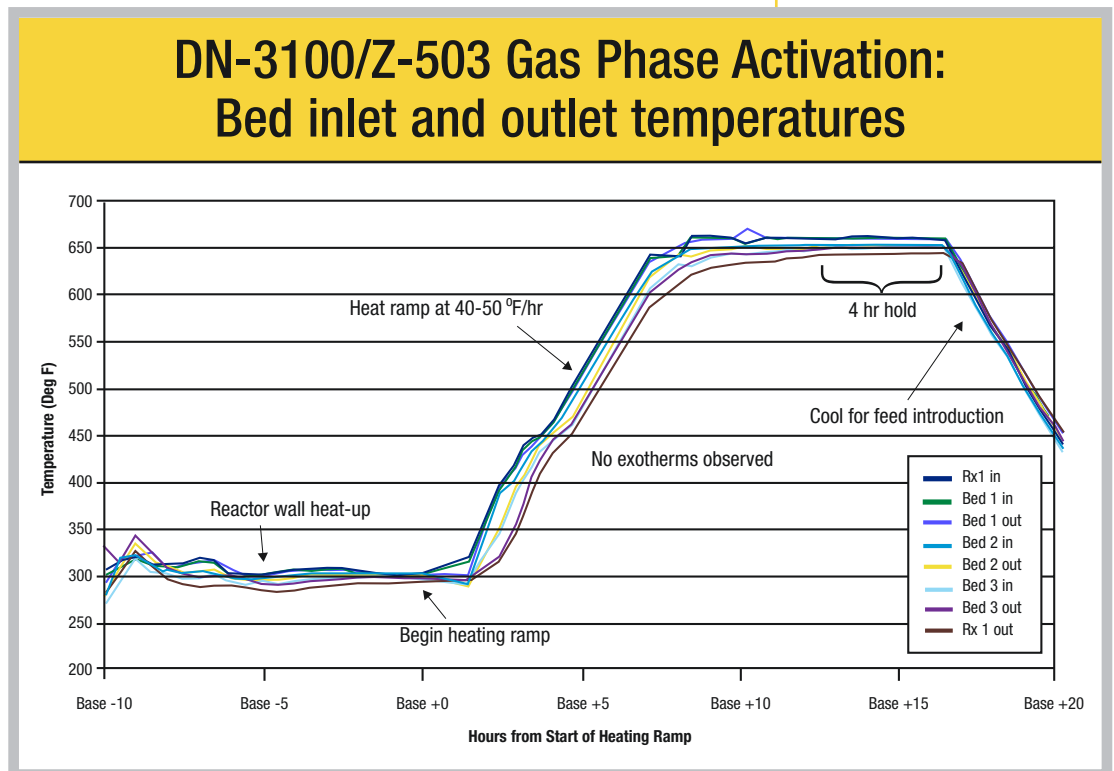


Deactivation rates remain below 1 °F/month. The catalyst has also shown robust performance against unit upsets and feed quality excursions.

Criterion CENTINEL™ DN-3100 - continued

Hydrotreating Catalyst Demonstrating Excellent Commercial Performance & Ease of Start-up

Users of DN-3100 have also seen the ease of start-up afforded by CENTINEL™ technology. No sulfiding agent injection or holds waiting for H₂S breakthrough are required. Sulfiding is complete after a smooth heating ramp and high temperature hold, as shown in the example below.



Criterion
CENTINEL
DN-3100

CENTINEL *SYNERGY* For Maximum FCC Pretreat Unit Performance

Get More FCC Gasoline Sulfur and SO_x Reduction

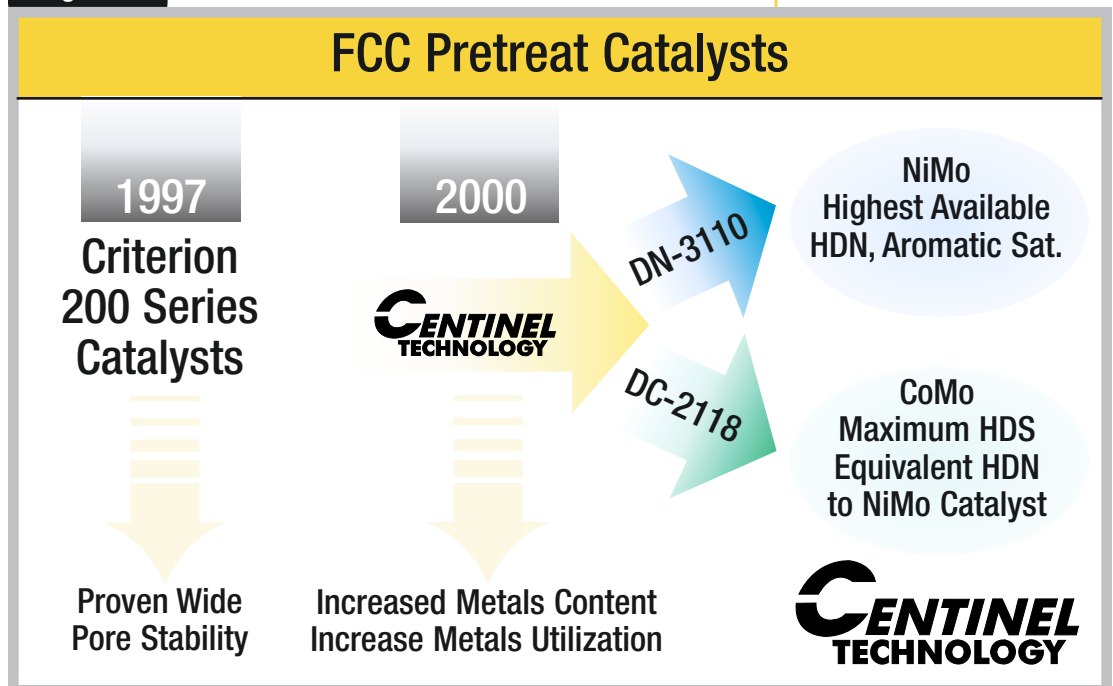
Over 500 thousand barrels per day of Fluid Catalytic Cracker (FCC) feed is being improved with CENTINEL catalyst technology.

The Benefits:

- Reduced FCC gasoline and LCO sulfur
- Reduced Regenerator SO_x emissions
- Increased FCC conversion

Criterion's CENTINEL DN-3110 and DC-2118 are the leading, proven catalysts for pretreatment of FCC feed.

Figure 1

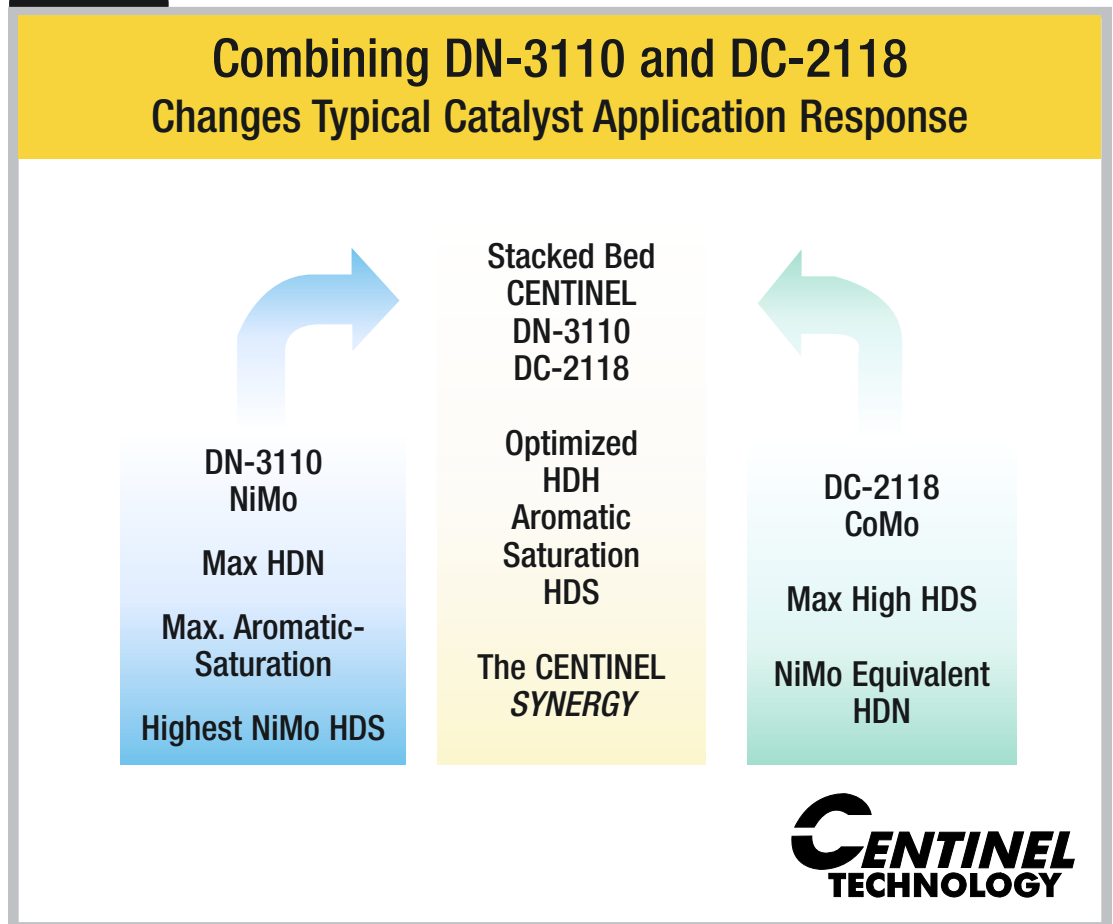


These catalysts have commercially proven that Criterion's research and development has once again developed step out products which improve FCC yields and reduce FCC product sulfur.

WHAT'S NEXT??

Catalyst system optimization and application “know how” have brought about the next milestones in CENTINEL catalyst performance in FCC Pretreatment service. Working with our customers, we have discovered a **SYNERGY** when applying the DN-3110 and DC-2118 CENTINEL catalysts together. FCC gasoline sulfur can be reduced even further and FCC yields can be improved by applying the CENTINEL Synergy.

Figure 2



Historically, maximum FCC feed desulfurization activity is achieved with a 100% CoMo application, like DC-2118 CENTINEL CoMo. By innovatively combining DN-3110 and DC-2118 catalysts, even better sulfur removal performance has been demonstrated in

both the laboratory and the field. The SYNERGY is achieved as “the result of the whole catalyst system is greater than the sum of the parts”. The benefits of the high nitrogen and aromatic saturation performance of DN-3110 NiMo catalyst work in concert with the increased

sulfur removal performance of DC-2118 providing synergistic sulfur removal performance. The CENTINEL SYNERGY approach provides an optimized solution designed to improve FCC yields, while reducing FCC product sulfur.

Figure 3

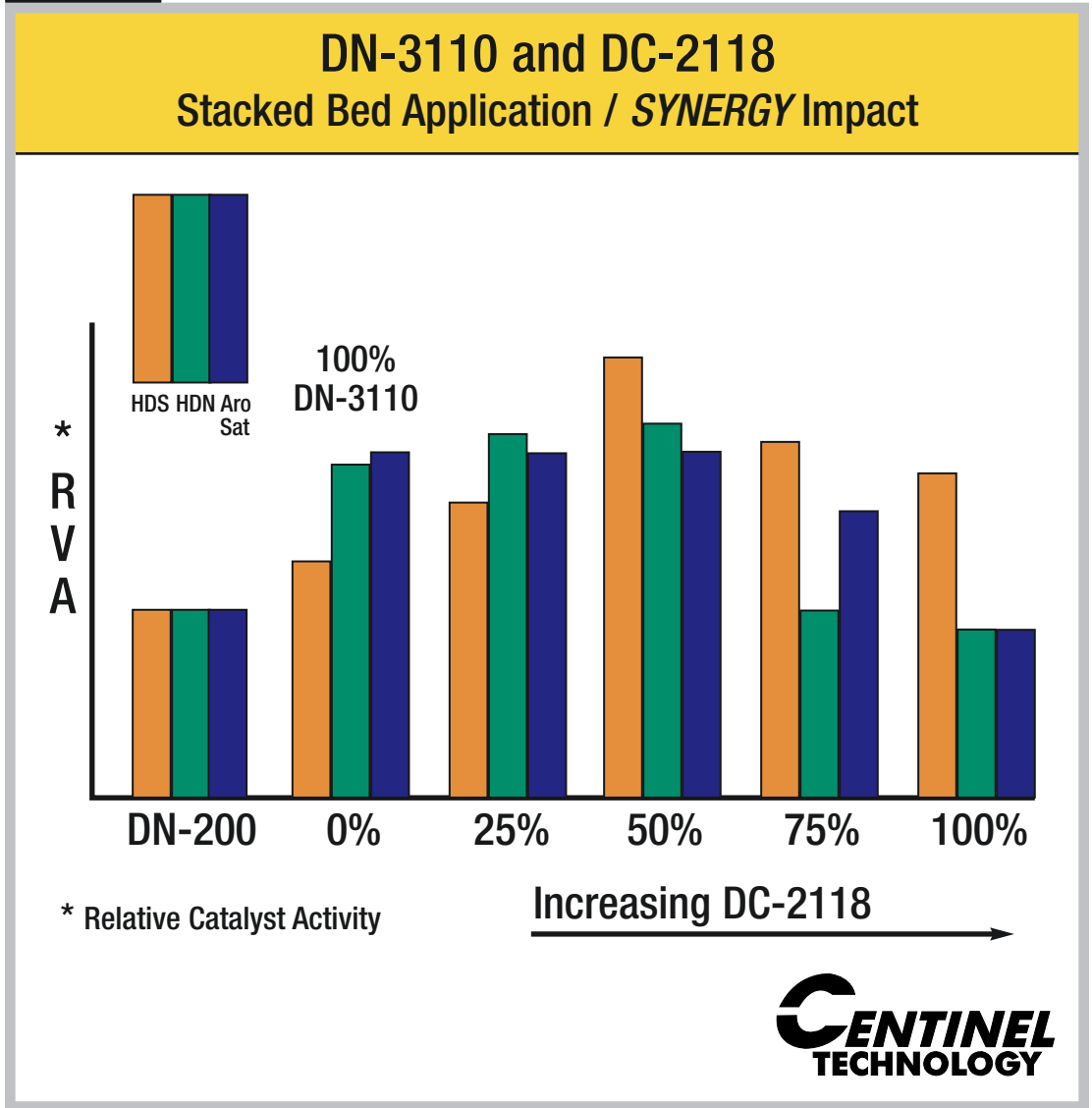


Figure 3 demonstrates the impact of the CENTINEL SYNERGY. In this example, the maximum desulfurization activity is not achieved with 100% DC-2118 CoMo, but rather with a stacked bed of 50% DN-3110/50% DC-2118 CENTINEL catalyst system. In addition, FCC feed quality

and FCC yields will improve as nitrogen removal and aromatic saturation activity are enhanced with the optimum CENTINEL SYNERGY catalyst system.

5 FCC Pretreat units are already enjoying the benefits of a CENTINEL SYNERGY catalyst system.

Catalyst application “know how” is the key to achieving the CENTINEL SYNERGY.

Contact your Criterion Catalyst and Technology representative for more detail.

Catalytic Reforming of Naphtha

From CCR catalysts to new fixed bed catalysts, Criterion provides leading-edge high performance reforming catalysts. Criterion's catalysts provide exceptional surface area stability and attrition resistance. With these catalysts, significant boosts to yields of reformate and hydrogen is achieved. Providing the refiner with economical solutions through catalysts to improve unit performance is our goal. Through innovative R&D, Criterion has the full range of reforming catalysts to add value for the refiner. Whether the goal is increased throughput, higher octane, or upgrading lower quality feedstocks, we can supply a catalyst to fulfill your needs.

We supply a variety of naphtha reforming catalysts for fixed bed (semi-regen and cyclic) and moving bed units. Criterion began manufacturing reforming catalysts for the extremely demanding cyclic-type reformers in the 1950's. Our unique manufacturing process enables us to make catalysts that have both high start-of-run C5+ yield and the best yield stability in the industry, which means they produce more octane-barrels per cycle than any other catalyst. Despite the long existence of reforming technology, we continue to achieve significant catalyst performance breakthroughs. Recent developments during the past 2 years have demonstrated C5+ yield gains of as much as 2 volume percent compared to our previous generation catalysts. These are our current key products.

PS-40

Our PS-40 reforming catalyst is designed to maximize C5+ yield and enable higher throughputs and/or higher octane production in continuous catalyst regeneration (CCR) reforming units. It incorporates the strengths of Criterion's earlier generation PS-10 and PS-20 catalysts, providing all-around excellent operability and the greatest amount of C5+ product. The alumina support for all these catalysts is designed to resist losses caused by abrasion and crushing, thereby minimizing the addition rate for make-up catalyst. The support's design also reduces the rate of surface area decline (better activity maintenance) and improves chloride retention (reduced downstream corrosion and reduced chloride chemical costs). Additionally, improvements incorporated into PS-40's formulation have reduced the degree of paraffin cracking, which results in more hydrogen and C5+ reformate and less coke make. PS-40's capabilities make it particularly well suited for CCR reformers constrained by the

quantity of coke that can be burned per hour in the regenerator. Since its introduction in 1998, PS-40 has established itself as the industry benchmark.

PR-11

Maximum yields within fixed bed reforming units are achieved by using a staged, synergistic system of catalysts to promote the desired reactions at the optimum reactor position. PR-11 is designed for the first and second reactors of the unit ("front end") where naphthene dehydrogenation is the desired reaction. This platinum/rhenium catalyst, developed by Criterion for coke stability and sulfur tolerance, also inhibits the undesired hydrolysis reaction (breaking of carbon-carbon bonds) that opens the naphthene rings and consumes hydrogen. The benefit to the refiner is a higher overall naphthene ring conversion to the preferred products - aromatics and hydrogen.

PR-9

This platinum/rhenium catalyst is designed for use in fixed bed reforming processes. When a staged catalyst system is utilized, this “back end” catalyst is often used in the third and fourth reactors with PR-11 in the first two reactors. PR-9 has been designed to reduce paraffin cracking, which is most likely to occur in the back end reactors. As a result, it preserves the hydrogen produced in the lead reactors and boosts the C5+ yield.

PR-29

Criterion’s PR-29 platinum/rhenium catalyst is also a “back end” catalyst used in fixed bed reforming processes. In addition to the reduced paraffin cracking advantage of PR-9, this skewed metal formulation (lower platinum, higher rhenium) promotes less dealkylation of aromatics. This provides the benefit of higher yields of C8+ aromatics and reduces the formation of benzene.

Our catalysts are backed up by extensive technical service including guidance on operating and regenerating catalysts as well

as data tracking and advice on unit optimization to increase profit.

As with all our application lines, outstanding catalyst performance is only half of the solution we provide to improve your reforming operations. Careful technical analysis and guidance built on years of experience in many different situations is the other half of the answer we provide to ensure you realize maximum benefits from our state-of-the-art catalysts.

Catalytic Reforming of Naphtha

PS-11

PR-29

PR-9 S-40

Criterion Catalysts For Hydroprocessing of Lubricating Oils and Waxes

Process Descriptions

Criterion has a long history of providing catalysts to lube refiners. Prior to the formation of Criterion, the Royal Dutch/Shell Group developed numerous catalysts effective in lubricating oil production. The best known of these, 424 and 454, remain in service after many years of successful use. Criterion 424 has been very effective for hydrofinishing and for pretreatment of lube distillates. Criterion 454 has been used successfully for over 20 years in lube hydrocracking units around the world. Numerous catalysts were also developed by American Cyanamid's Chemical Products Division.

Hydrofinishing

This application includes both the finishing of oils previously refined by solvent extraction or hydrocracking and the hydro-treatment of straight-run lube distillates into finished lube products. These lube products include both naphthenic and paraffinic oils. While severity can vary widely in pressure,

space velocity and temperature, lower temperatures are preferred to minimize viscosity loss and minimize product PNA content. The main objectives are color improvement as well as the saturation of aromatics and olefins and the removal of sulfur, nitrogen and oxygen. Criterion has historically supplied numerous catalysts for this application, such as HDS-3, HDS-9, HDN-60 and 411. Criterion's highly successful 424 and DN-190 have seen extremely wide usage in lube and wax processing. Criterion now offers CENTINEL products, including DN-3100 and DN-3110, in addition to the aforementioned 424.

Pretreating

The same catalysts used for hydrofinishing are also very effective for pretreating lube oil fractions prior to further processing. Such pretreating prepares the oil for processing over catalysts sensitive to sulfur and nitrogen, most typically for the production of FDA quality oils and waxes as well as for pour point reduction.

VI Improvement by Hydrocracking

This process, first commercialized in 1970, can produce Group II and III lube oils. In this process, a low to moderate conversion hydrocracking step replaces solvent extraction for increasing VI and removing undesirable components. This process can economically produce lube oils from a wider variety of crude oils and at higher yields than is possible with solvent extraction. In addition, such a hydrocracker can also economically complement an existing solvent extraction unit. Criterion continues to offer its long proven 454 for use in these lube hydrocrackers. Criterion has recently introduced new catalysts that offer improved performance for lube hydrocracking without the need for fluorine promotion. Shell Global Solutions offers this technology for license.

Food Grade Oil and Wax Production

Food grade oils, originally produced by acid treating, are now most commonly produced by high severity hydrogenation. Criterion's catalyst offerings for this process include both high activity hydrotreating catalysts for the initial processing of the feedstocks for these products (see pretreating catalysts, above), and extremely high activity finishing catalysts capable of surpassing demanding FDA specifications. High activity finishing catalysts include both Criterion noble metal catalysts and KataLeuna nickel catalysts. The noble metal catalysts offer very stable operation with resistance to poisoning by sulfur and nitrogen. Nickel catalysts offer excellent performance in units with very low sulfur content feedstocks. Criterion's catalysts have enabled white oil refiners to increase throughput, improve product quality, and significantly extend cycle lengths. Lyondell Licensing offers their Duotreat Process for the production of these oils.

Catalytic Dewaxing and Wax Isomerization -

Criterion supplies catalysts used by Shell Global Solutions International in the technology areas of catalytic dewaxing and of isomerization/conversion of waxes to produce lubricants of exceptional quality. *For more information, please see our Technology section.*

Lube Oil and Wax Refining Technologies

In addition to offering catalysts and catalyst related technical services to the refining industry, Criterion cooperates with Shell Global Solutions to offer refiners the latest in process technology. Shell Global Solutions not only offers refining process technology licenses, but also customized engineering technical services that can support all aspects of a refiner's operations. Shell Global Solutions is a leader in lubricating oil and wax production and in refining technology, with technology offerings including hydrocracking, wax isomerization and conversion, hybrid technology for

debottlenecking lubricating oil production facilities, and hydrofinishing. Criterion also maintains an alliance with Lyondell Licensing, providing catalysts for Lyondell's Duotreat technology for the production of FDA oils and waxes. Lyondell is a technology provider with a long history in both lube hydroprocessing operations and licensing. Criterion personnel can discuss your refining needs with you, enlisting the aid of these technology providers as needed to assist you in reaching your refining goals.

Criterion Catalysts For Hydroprocessing of Lubricating Oils and Waxes

Important:

All information contained in this document is considered accurate at the time of the testing, based on the equipment, and specific conditions and other limitations during the testing process. It is being furnished upon the express condition that the user will make its own assessment to determine the accuracy and applicability for the user's particular purpose.

Copyright Criterion Catalysts & Technologies, 2002



Worldwide Offices:

HOUSTON:

16825 Northchase Dr; Suite 1000
Houston, Texas 77060-6029
Telephone: (281) 874-2600
Facsimile: (281) 874-2641

CANADA:

Suite 810, Centre 104
5241 Calgary Trail Southbound
Edmonton, Alberta T6H 5G8
Canada
Telephone: (1) 780-438-4188
Facsimile: (1) 780-438-3473

UNITED KINGDOM:

1650 Parkway
The Solent Business Park,
Whiteley, Fareham,
Hampshire, PO15 7AH
England
Telephone: (44) 1 489-881881
Facsimile: (44) 1 489-881882

SINGAPORE:

298 Tiong Bahru Road
#07-03 Central Plaza
Singapore 168730
Telephone: (65) 6276-3627
Facsimile: (65) 6276-7455

LUXEMBOURG:

Route de Longway, 420
L-4832 Rodange,
Luxembourg
G.D. of Luxembourg
Main Tel#: (352) 502-454
Catalyst Regeneration Services
Main Fax#: (352) 502-996

Visit us on the web: www.criterioncatalysts.com

e-mail address: publicaffairs@criterioncatalysts.com

