

# High-performance catalysts and technology in action

## WES COTTON CRITERION CATALYSTS & TECHNOLOGIES

As environment regulations continue to get stricter, refiners are being challenged to provide cleaner transportation fuels while, at the same time, processing more difficult crude slates. Following an early adoption in Europe, US and Japan, ultra low-sulphur diesel (ULSD) standards continue to be implemented globally. Significant investment has been made recently in India and China to migrate to Euro IV and Euro V grade fuels respectively. The recent IMO decision to reduce sulphur in bunker fuel to 0.5 wt% by 2020 presents another challenge. Catalyst suppliers have a key role to play in this on-going transition. Criterion Catalysts & Technologies has over three decades of experience in applying customised catalyst solutions and operating strategies to help refiners improve yields, process challenging feeds and maximise profitability.

Launching in 2017, Criterion's latest technology, Centera GT, builds on the fundamentals of the original Centera family while incorporating enhancements to the catalyst carrier as well as molecular structure of the active metal sites. The accelerated development of Centera GT is a direct result of investing in computational modelling, deploying high throughput catalyst testing and leveraging state-of-the-art characterisation method and data analysis tools. Atomically specific modifications to the alumina carrier have resulted in the creation of novel nanoscale features as well as a more desirable set of physical and chemical properties. The modified carrier enabled Criterion's scientists to engineer highly dispersed MoS<sub>2</sub> particles with step-out intrinsic activity for HDS, HDN and HDA. The effect was so pronounced that it provided the highest active metal site utilisation observed for alumina supported catalysts. Advanced catalyst characterisation methods, including aberration corrected Scanning Transmission Electron Microscopy (STEM), were critical to the development of Centera GT.

**Figure 1** shows HDS activity for two new ULSD catalysts, DN-3638 and DC-2638, at 60 and 40 bar respectively. Both exhibit more than 20% HDS and HDN activity improvement compared to their Centera predecessors.

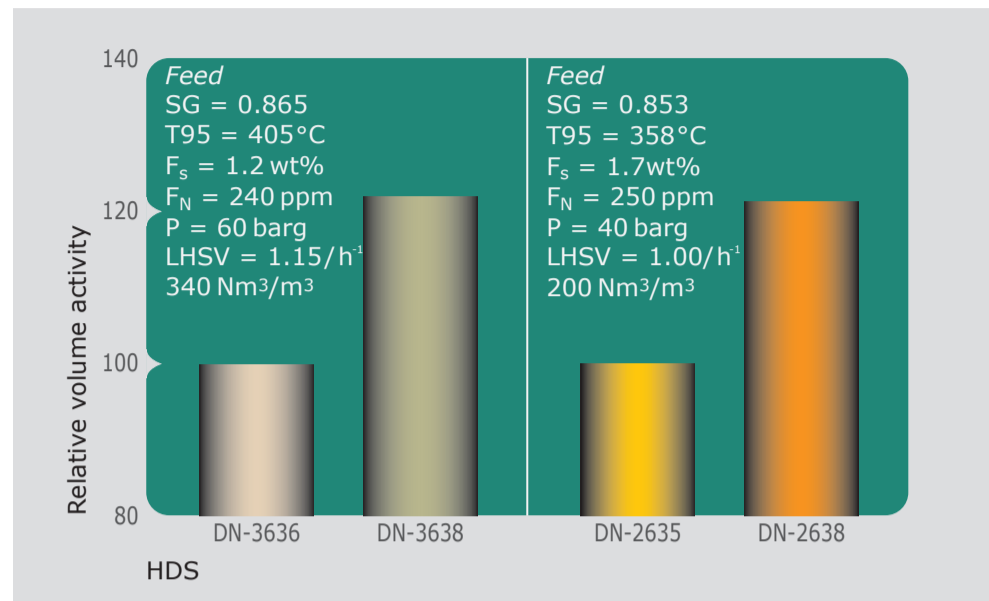
The step-out activity of Centera GT can

be utilised in several ways to improve unit performance. DC-2638 is ideally suited to units processing challenging feeds at low hydrogen partial pressure, which require robust HDS activity with limited H<sub>2</sub> consumption. The synergistic effect of a CoMo/NiMo/CoMo stack is employed in medium-pressure units that process refractory, higher nitrogen feeds such as light cycle oil (LCO) or light coker gas oil (LCGO), but are H<sub>2</sub> constrained. The enhanced HDN activity of the NiMo layer reduces the organic nitrogen going to the bottom CoMo layer, resulting in a synergistic boost in HDS performance. Such a system enables a unit to maximise the rate of high margin feeds such as LCO and LCGO without a significant H<sub>2</sub> consumption penalty. Criterion was the first to apply this concept to distillate units in the early 2000s. Over the years, we have continued to build the modelling tools and

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expertise needed to optimise the catalyst design depending on the unit conditions and requirements.

Sites with access to low-cost H<sub>2</sub> can use the enhanced saturation activity of DN-3638 to push aromatic saturation, maximise volume swell and cetane improvement. The resulting low-sulphur diesel product (<5 ppm) is a valuable blending component to maximise overall refinery diesel yield. Another way to take advantage of higher activity catalysts is to free up reactor volume for beyond ULSD applications such as dewaxing or distillate mild hydrocracking (MHC). Dewaxing



**Figure 1** Centera GT DN-3638 and DC-2638

improves the cold flow properties of the ULSD product, while distillate MHC uses a low-activity hydrocracking catalyst to enable processing of heavier feeds. One refinery achieved a 7% higher diesel yield by maximising T95 shift using a combination of high-activity NiMo catalyst and diesel-selective MHC catalyst. The unit continues to deliver profit improvement of 6-9 MM \$/year.

The performance of a hydroprocessing unit is dependent not only on the catalyst system, but also on the reactor and internals design. Uniform gas and liquid flow distribution in the reactor is essential for good catalyst utilisation and optimum unit performance. Use of older generation reactor internals leads to substandard catalyst performance and substantial lost opportunity. Criterion's licensing partner, Shell Global Solutions, has developed several reactor internal improvements, such as its High Dispersion (HD) distributor trays, Filter Trays and Ultra-Flat Quench trays. These improved internals produce excellent flow distribution over a wide range of conditions. The HD trays have been particularly helpful in boosting the performance of older hydroprocessing units. Employing these custom-designed trays can produce as much as 30-50% activity gain through the improved catalyst utilisation and extra volume for loading catalyst. The internals are designed for easy assembly and reassembly, thus minimising the

exposure of maintenance personnel to a high-risk environment inside a reactor and reducing turnaround time.

Criterion has been leveraging digital technologies such as advanced analytics and high-performance computing to enable seamless sharing of data and auto-identification and notification of outliers in unit performance. Criterion's CatCheck Advisor is a virtual 'tech services' assistant that utilises machine learning algorithms and pattern recognition to provide high-level recommendations based on data analysis and catalyst performance. It includes web access to kinetic models tuned to the actual performance of the unit, which are used by customers to track KPIs such as conversion, yields and catalyst activity. The kinetic models can be used to evaluate what-if scenarios and case studies, as well as generate LP vectors. Digitise your catalyst experience now.

In conclusion, Criterion continues to push the boundaries of hydroprocessing catalyst R&D by leveraging emerging technologies to accelerate development and tailor molecular properties for step-out performance. Our high-performance catalysts combined with excellent technical service and advanced monitoring tools help refiners maximise return from their assets in these challenging times. ■

**Contact:** Wes.Whitecotton@shell.com



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Crambeth Allen Publishing Limited  
 Publisher of PTQ & DigitalRefining.com

**Business Development Director**  
 Paul Mason  
 Tel: +44 (0)844 5888 771  
[sales@petroleumtechnology.com](mailto:sales@petroleumtechnology.com)

**Production Editor**  
 Rachel Storry  
[production@petroleumtechnology.com](mailto:production@petroleumtechnology.com)

**Graphics Editor**  
 Rob Fris  
[graphics@petroleumtechnology.com](mailto:graphics@petroleumtechnology.com)