



# RESIDUE UPGRADING USING EBULLATED-BED HYDROCRACKING

Dealing more effectively with the bottom of the barrel is high on the refining industry's agenda for the following reasons. Crude oil feedstocks are becoming heavier, which is making lighter crudes more expensive. Environmental pressures are undermining the market for heavy fuel oil. In addition, the demand for clean transportation fuels is growing, with countries such as China and India taking the lead.

Ebullated-bed residue hydrocracking is a well-proven technology that creates value from even the most challenging residue feeds. The process is offered by two licensors. There are currently 14-ebullated-bed residue hydrocracking units in operation around the world with a total capacity in excess of 0.6 MMbbl/d. In the next five years, several additional H-Oil<sub>RC</sub> units will come on-stream and raise the total processing capacity to more than 0.8 MMbbl/d. Of the 14 units in operation, 9 use customised catalysts from Criterion Catalysts & Technologies.

Significantly, no two of the Criterion-supplied ebullated bed residue hydrocracking units are alike: feedstocks, product slates, the disposition of the products and the unconverted bottoms vary considerably. Customised catalysts are the key to successful operations. Criterion's catalyst development programme consequently plays a huge role in optimising the performance of these units.

**SEDIMENT CONTROL IS CRUCIAL TO  
THE PERFORMANCE OF EBULLATED-BED  
RESIDUE HYDROCRACKING.**

## CATALYST BENEFITS

Refiners with existing units have the flexibility to

- **raise conversion levels**
- **process heavier feeds**
- **improve product quality**
- **lower fresh catalyst addition rates.**

## PROCESS CHALLENGES

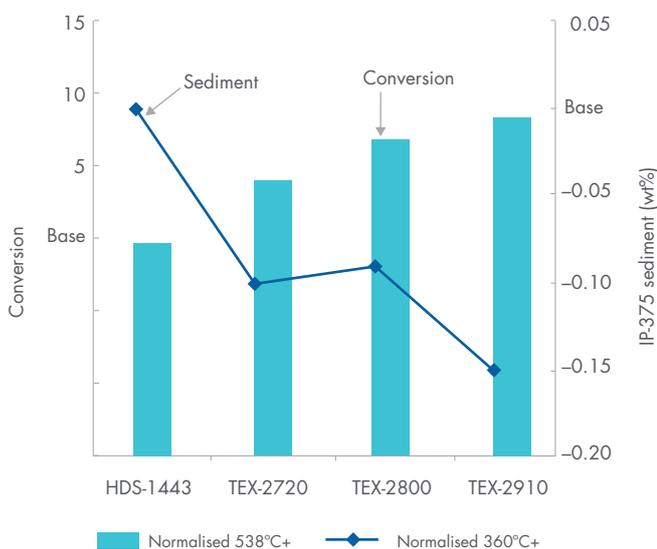
Ebullated-bed residue hydrocracking units are favoured by operators seeking high conversion (up to 85% 524°C+) of very refractive vacuum residue feeds with high metal contents and Conradson carbon residue (CCR) values. The ability of the technology to process difficult feeds such as bitumen effectively at high conversion levels is largely due to the fact that catalyst can be replaced online during operation. Typically, a small percentage of the catalyst is replaced on a daily basis. Cost is obviously a major consideration on this basis, which means that catalyst stability is a very important parameter.

Unit operability is strongly affected by any sediment produced in the process. Sediment often causes severe fouling of the reactor and major downstream equipment such as separators, product filters, heaters, fractionators and heat exchangers. It can also affect the quality of any products that include unconverted bottom streams. For these reasons, sediment control is an important catalyst feature. In addition, the process may sometimes be constrained by the operating temperature, which calls for catalysts with high activity.

# CRITERION'S CUSTOMISED CATALYSTS PROVIDE A DROP-IN SOLUTION FOR EBULLATED-BED RESIDUE HYDROCRACKER OPERATORS SEEKING TO IMPROVE UNIT OPERABILITY AND MAXIMISE CYCLE LENGTH.

## TECHNOLOGY LEADER

Criterion was the first company to introduce an ebullated-bed residue hydrocracking catalyst specifically developed to control sediment formation. This was in 1994 and the catalyst was TEX-2710. Since then, Criterion has made several significant advances and commercialised a series of catalysts that exhibit better sediment control and show higher conversion activity, as the figure below shows. These catalysts have proved to be very effective in upgrading notoriously difficult feeds, including vacuum residues from Middle Eastern, Urals and Mayan crude oils, and also in the treatment of bitumen to make synthetic crudes.



### Catalyst development

HDS-1443 was a first-generation, conventional ebullated-bed catalyst. TEX-2720 was an advance on TEX-2710, our first sediment control catalyst. TEX-2910 represents the latest generation of Criterion catalysts for two-stage ebullated-bed hydrocracker upgrading of residues from Middle Eastern crudes, as it is optimised for both sediment control and bottoms conversion. TEX-2910 is the incumbent catalyst in the Motiva Convent ebullated-bed hydrocracker.

## CONTACT US

For more information about how we can help you to enhance operational performance, meet increasingly stringent environmental regulations and increase revenues, visit us at [www.criterioncatalysts.com](http://www.criterioncatalysts.com).

## COMBATING SEDIMENT FORMATION WITH CUSTOMISED CATALYSTS

Sediment falls into two classes: Type I inorganics and coke, and Type II, arguably the worse culprit, precipitated asphaltenes. High in sulphur, nitrogen, oxygen and metals, and relatively insoluble, asphaltenes are the most complex and least characterised of all the heavy oil macromolecules. They are colloiddally dispersed in the oil and sit at the heart of the so-called SARA matrix (saturates, aromatics, resins and asphaltenes) that characterises all heavy oils. The colloidal instability index, defined as

$$\frac{(\text{asphaltenes} + \text{saturates})}{(\text{resins} + \text{aromatics})}$$

is particularly important, as it largely dictates the extent of sedimentation and also the maximum level of conversion that can be achieved before fouling limits operations. Understanding the SARA matrix, which is different for each heavy oil, and its behaviour is crucial to designing effective catalysts for successful residue upgrading.

Choosing the best catalysts to function under the specific conditions prevailing in an ebullated-bed residue upgrader requires considerable understanding. At Criterion, we take what we call the 4Cs approach. It is important to be clear about the **chemistry** of what you are trying to achieve: removal of metals, sulphur, CCR and asphaltenes. The **composition** of the feed is key, especially the nature and behaviour of the SARA matrix. In addition, the **conditions** within the unit, the operating constraints and the way the process is configured will clearly have a bearing on the way forward. By getting to grips with these numerous variables on an individual unit basis we can customise **catalyst** systems that meet individual refiner's needs.

Criterion Catalysts & Technologies LP is a wholly owned affiliate of CRI/Criterion Inc. It supplies total packages of catalysts, services and solutions for refineries and is a leading provider of hydroprocessing, reforming, and specialty catalysts.

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CRITERION and its affiliates are dedicated to providing a broad customer base with effective and cost-efficient catalysts and technologies available in focus areas that include the entire range of hydroprocessing applications.

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