HOW FOULING ABATEMENT SOLUTIONS CAN UNLOCK MILLIONS OF DOLLARS PER YEAR FROM YOUR REACTOR

WHITE PAPER

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HOW FOULING ABATEMENT SOLUTIONS CAN UNLOCK MILLIONS OF DOLLARS PER YEAR FROM YOUR REACTOR

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1. WHY FOULING ABATEMENT IS THE FIRST STEP TO UNLOCKING MAXIMUM VALUE FROM YOUR REACTOR

The performance of latest-generation distribution trays and interbed internals can be dramatically curtailed if foulants enter the catalyst bed.

There is an increasing awareness in the industry that refiners can substantially improve the profitability of their hydroprocessing reactors by installing the latest-generation reactor internals.

However, the importance of taking steps to prevent foulants from reaching those trays and internals is often underappreciated. Fouling can diminish their performance. Moreover, most refineries are seeing increased fouling because of the trend towards processing increasingly difficult feeds.

Fouling of catalyst beds causes unwanted pressure drop increases that limit the performance of many hydroprocessing units. The resultant issues can include short run lengths, unplanned downtime costs, unused catalyst activity, increased maintenance and lost revenue.

The fouling challenge is complex and depends on the type of feed, the upstream processing and the unit operating conditions.

At Shell Global Solutions, we leverage our 25 years of dedicated research and experience in fouling abatement with Shell-affiliated, Shell-serviced and non-Shell refineries to help you identify the root cause of fouling and to develop solutions. These will often feature our proprietary, proven anti-fouling trays: Shell scale-catching trays, Shell filter trays and Shell filter and sedimentation trays (FAST).

2. WHAT IS FOULING?

Fouling is one of the key issues affecting the reliability of hyd roprocessing reactors. Understanding the origin and characteristics of fouling is essential to tackling the issue.

Fouling is defined to be a problem when some or all of the following conditions are met:

- the run length of the unit is limited by pressure drop across the reaction section instead of catalyst activity (see Figure 1);
- the pressure drop increase of heat exchangers is such that the available hardware systems (intermittent or continuous wash-water systems) or cleaning procedures cannot cope with it;
- fouling deposits initiate or accelerate unpredicted corrosion mechanisms, thereby threatening the integrity of the unit;
- throughput and operational flexibility are reduced; and
- energy and maintenance costs are increased.

There are various types of foulant, including:

- inorganic particulates such as iron sulphide (see Figure 2), sodium, coke particles (see Figure 3) and catalyst fines;
- organic deposits such as gum (see Figure 4), coke, organometallic contaminants and asphaltenes; and
- ammonium salts such as ammonium chloride and ammonium bisulphide.

Fouling occurs in different locations, including the reactor top, the feed/effluent heat exchangers, the reaction section air coolers, the high-pressure separator and the recycle gas compressor. Knowledge of the type of fouling and the underlying deposition mechanism is essential to tackling fouling problems.
FIGURE 1: As foulant particles build up, there is a large increase in the pressure drop ($dP$), which constrains the unit’s performance.

FIGURE 2: Iron sulphide deposits on top of the catalyst bed.

FIGURE 3: Coke particles on the feed side of the feed–effluent heat exchangers.

FIGURE 4: Gum formation in the catalyst bed.
3. A THREE-TIERED APPROACH TO FOULING ABATEMENT

Shell Global Solutions has developed a three-tiered approach to fouling abatement (Figure 5) that can be tailored for your refinery operations. The fouling abatement team will help you to look behind the apparent issue to identify and address the root cause of fouling.

**Tier 1. Determine the cause and location of the fouling problem by:**
- performing a detailed investigation of past operations and feed handling. This includes analysis of operating data, feed quality and feed handling. Video documentation of the unloading process at the end of run often provides clues to the location and type of foulant.
- using proven reactor sampling techniques. Shell BedCore® will facilitate a detailed laboratory analysis by extracting samples up to 2-m long from the top layer of the catalyst bed (see Figure 6).
- providing sample analysis at Shell laboratories. Relevant feed and spent catalyst sample analyses help to determine the foulant’s source and provide data for solution development.

**Tier 2. Devise an improved fouling abatement strategy and assist the refiner with implementation using:**
- top-bed grading for fouling abatement. Various shapes and sizes of bed grading are used to spread out the foulant (see figures 7 and 8). This process is designed so that no layer of bed grading becomes overwhelmed or underutilised. Our technology, based on cold-flow research, enables us to evaluate the size and shape of bed-grading materials to tailor the solution to the specific unit characteristics and to extend your run length. Fouling abatement solutions are based on experience and supported by our research activities.
- in-house experience and synergies through affiliations. Shell Global Solutions benefits from the experience of the Shell Group’s global catalyst technology company, Criterion Catalysts & Technologies (Criterion), and relationships with Shell-affiliated refineries. These in-house capabilities and synergies through affiliations bring the added benefits of many years of operating experience, research and development, catalyst development and manufacturing. We apply lessons learned for your benefit while maintaining confidentiality.

**FIGURE 5:** Shell Global Solutions’ three-tiered approach to fouling abatement.

**EVALUATE THE RESULTS AND REFINE THE SOLUTION**
- Evaluate grading schemes
- Reactor internals
- Feed filters

**DEVISE AN IMPROVED FOULING ABATEMENT STRATEGY**
- Top-bed grading for fouling abatement
- In-house experience and synergies

**DETERMINE THE CAUSE AND LOCATION OF THE FOULING**
- Investigate past operations
- Catalyst/grading sample analysis
- Feed analysis

Shell BedCore is a Shell trademark.
Tier 3. Evaluate the results and refine the solution using:

- an evaluation of grading schemes. Our proprietary catalyst sample baskets can test alternative bed-grading solutions in your reactor with or without changing the current grading system.
- reactor internals. Reactor internals can sometimes be a more economical way to address specific foulant sources. Shell Global Solutions offers proprietary reactor internals that are designed to trap foulants and to reduce the rate of pressure drop increase on all types of reactors in fouling service (for more details on the Shell reactor internals portfolio, see Section 8).
- feed filters. Consultation on the application of traditional and automatic backwash filters is available from Shell Global Solutions’ filtration experts.

**FIGURE 6:** Shell BedCore provides in-situ sampling of catalyst beds. A pneumatic hammer pushes a corer into the bed to gather a sample (left). Samples (right) up to 2-m long can be taken in one go in an inert atmosphere. This has been shown to be a highly accurate method of sample gathering.

**FIGURE 7:** Designing the grading scheme requires experience and extensive knowledge of the foulants’ nature and filtration mechanisms. The use of a proper grading scheme can significantly increase the catalyst bed’s cycle length by avoiding the formation of a dense layer of particles (cake filtration), as shown in this photograph.
<table>
<thead>
<tr>
<th>Size(s), MM</th>
<th>Void, %</th>
<th>Activity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OptiTrap [Medallion]</strong></td>
<td>16</td>
<td>65–70</td>
</tr>
</tbody>
</table>
| ■ Inert  
■ High void  
■ Flow improvement | | | |
| **OptiTrap [MacroRing]** | 8 | 55–60 | 20–30 |
| ■ Macroporous  
■ High void  
■ Low activity | | | |
| **OptiTrap [Ring]** | 6.4  
4.8  
3.2 | 50–55 | 30–50 |
| ■ High void  
■ Good activity | | | |
| **OptiTrap [FilterLobe]** | 5.6  
3.2  
2.5 | 40–45 | 40–50 |
| ■ Large diameter  
■ Extra long trilobe | | | |
| **Interlayer [NiMo]**  
**Interlayer [CoMo]** | 2.5  
2.5 | 35–40 | 100 |

**FIGURE 8:** Short list of Criterion’s SENTRY top-bed grading solutions showing their different sizes and shapes, and indicating how multiple layers of grading can control particle admittance (function of void) and gum formation (function of activity).
4. FOULING ABATEMENT OUTSIDE THE REACTOR

4.1 Good housekeeping
Successful fouling abatement starts with continuous good housekeeping, particularly in avoiding significant ingress of external particulate matter that can overwhelm any filter system. This includes frequent draining of water from storage tanks; timely changing out of feed filters or adsorbent materials; proper installation of reactor internals; proper loading of catalyst beds; and regular monitoring of feed, products and sour water.

4.2 Feed filtration
Feed filters are not commonly applied in hydrotreating and hydrodesulphurisation units, but it is normal practice to install them in hydrocrackers and residue conversion units. They are located upstream of the reactor charge pump and are used in fresh feed service and often in recycle feed service.

Although feed filters offer the opportunity to prevent solid particles present in the feed from entering the reactor, they are expensive and often laborious to operate, which results in frequent bypassing of the filters. Furthermore, feed filters are installed before the high-pressure circuit and will, therefore, not be effective in removing solids that form or tend to agglomerate at high temperature and pressure conditions. Therefore, a second line of defence such as top bed grading, which will be discussed in Section 5.1, is necessary.

Feed filters fall into three main categories:
- **cartridge filters**, which are simple and relatively inexpensive, but have limited capacity. These are most appropriate for low- to medium-severity fouling conditions when cleaning is not very frequent.
- **backwash filters**, which are often applied in high-solid-load, automatic backwash systems. They have a much larger filtering capacity than cartridge filters, but are more elaborate and significantly more expensive.
- **deep-bed filters**, which are more suitable for when the particulates in the foulant material are small. The deep-bed filter is located downstream of the normal feed filter in a vessel separate from the reactor. This option is not commonly used, as a large volume is required for the uptake of a small amount of foulant material and it can be vulnerable to cake filtration.

4.3 Guard reactors
The purpose of a guard reactor is to selectively hydrogenate gum precursors. It is filled with NiMo catalyst topped with low-activity, high-voidage material. It may be located in the middle of the heat exchanger train.
5. FOULING ABATEMENT INSIDE THE REACTOR

Depending on the severity of the feed and the source and nature of the foulant material, top-bed grading and anti-fouling reactor internals may be required above the top catalyst bed of the reactor.

5.1 Top-bed grading
To reduce the impact of particulates on pressure drop, fines have to be accommodated in the bed without drastically reducing the available area for fluid flow. The desired uptake mechanism for the accommodation of fines is deep-bed filtration.

To this end, a system of multiple grading material layers of different sizes and activity is required. Low-activity, high-voidage grading materials suppress gum formation by hydrogenating gum precursors (diolefins) and iron-containing organic compounds. Additionally, they offer void space to accommodate any deposits that form. Each layer of the graded-bed system traps (with the deep-bed filter) particles that could otherwise block (by cake filtration) the layer below.

5.2 Shell reactor internals
Depending on the results of the fouling analysis and in addition to the top-bed grading, we can offer Shell scale-catchting trays (Figure 9), Shell filter trays (Figure 10) and Shell filter and sedimentation trays (FAST) (Figure 11).

These are designed to:
- limit fouling by trapping foulants before they enter the catalyst bed, which leads to a slower increase in pressure drop and a consequent longer cycle length;
- break up the liquid stream from the inlet device; and
- provide general distribution to the Shell high-dispersion (HD) tray below.

They offer additional filtering capacity by trapping contaminants and sediments, and have the benefit of enabling a higher catalyst loading capacity by minimising the height of the top-bed grading layers and significantly delaying any reactor pressure drop increase due to fouling (Figure 12).

The scale-catching tray is the standard Shell technology for physical separation by gravity between (solid) particles and fluid. Its typical storage space is equivalent to 0.2 m of bed grading. For trickle-flow reactors, it also serves as pre-distribution tray for the distributor tray. For vapour phase units, its main purpose is to catch liquid during startup and upsets, and capture foulants. The tray only collects the larger (scale) particles, whereas the smaller particles are entrained with the gas and/or liquid.

For more severe fouling duties, replacement of the standard scale-catchting tray by a top-bed filter tray can be considered for trickle-flow units. Note that the filters of the filter tray have to be filled with the smallest (spent) catalyst particles present in the reactor.
FIGURE 9: The scale-catching tray. This is the standard Shell technology for physical separation (by gravity) of particles and fluid. The tray only collects the larger (scale) particles, while the smaller particles are entrained by the gas and/or liquid. This tray is, therefore, especially suitable when fouling analysis concludes that most of the particles are large.

FIGURE 10: The Shell filter tray. For more severe fouling duties, a top-bed filter tray should be considered for trickle-flow units. The filter elements of the filter tray are filled with the smallest (spent) catalyst particles in the reactor to enable filtration of the smallest size particles. A recent development in easy-to-open filter elements enables a significant reduction in tray cleaning and maintenance time. The storage capacity of top-bed filter trays is typically equivalent to a height of 1 m of optimised bed grading.

FIGURE 11: The Shell filter and sedimentation tray (FAST). V-wire filter elements of the same height can replace the filter elements on the filter tray. They use surface filtration to retain particles and have the advantage of a higher storage volume on the tray and easier cleaning. However, their filtration cut-off size is fixed by the V-wire’s slit width and is not variable, as with the element filling.

FIGURE 12: Top-bed catalyst loading scheme using Shell filter trays.
6. THE VALUE OF SHELL’S FOULING ABATEMENT TECHNOLOGIES

Shell scale-catching trays, Shell filter trays and Shell filter and sedimentation trays (FAST) offer an outstanding cost–benefit ratio.

By applying Shell’s fouling abatement technologies, refiners may be able to benefit from:

- **an enhanced cycle length:** Studies have shown that these components can significantly delay a reactor’s pressure drop increase, thereby helping to increase cycle length by up to 300% (see Section 7.1).
- **a shorter catalyst unloading time:** Less fouling has the benefit of a shorter catalyst unloading time, as catalyst beds that are not heavily fouled are easier to unload.
- **quicker cleaning:** Shell’s new quick-to-open filter elements make cleaning the filters simple and fast.
- **Shell’s design expertise:** Shell’s fouling abatement trays are installed in the unoccupied top dome of the reactor to maximise catalyst loading capacity and are assembled without welding or bolting for quicker and safer installation.

7. CASE STUDIES

The following case studies show how operators have prevented fouling from constraining unit performance by collaborating with Shell Global Solutions and Criterion.

7.1 Shell Martinez refinery catalytic feed hydrotreater (CFH) guard reactors

Two reactors in parallel guard the CFH at the Shell Martinez refinery in the USA. However, they had a history of pressure drop build-up that had been linked to non-filterable dissolved iron in the CFH feedstock that averaged about 2,300–2,700 kg/y. The pressure drop build-up reduced the recycle gas flow as the end of run was approaching. This caused accelerated catalyst deactivation. Furthermore, the pressure drop build-up in the CFH resulted in a shorter run length and poorer performance towards the end of run.

Installing a Shell filter tray at the top of both reactors led to an increase in the days on-stream of more than 300%, as shown in Figure 13.

![Figure 13: The CFH’s days on-stream increased by over 300%.]
7.2 US refinery gas oil hydrotreater (GOHT)

A GOHT in a non-Shell refinery in the USA had previously experienced high pressure drop across the reactor beds that was limiting the cycle length to about 9–12 months. Attempts at modifying the grading scheme extended this slightly to 14 months.

Next, the refiner revamped the reactor by replacing all the existing internals with Shell internals, including installing a Shell filter tray at the top. This resolved the pressure drop issue and the cycle length increased to more than 30 months, as shown in Figure 14.

![FIGURE 14: Installing a Shell filter tray resolved the pressure drop issue and increased the GOHT’s cycle length to more than 30 months.](image1)

7.3 North Atlantic Refining’s hydrocracker

North Atlantic Refining’s hydrocracker in Canada experienced high pressure drop across the reactor beds that was constraining its cycle length. The refiner tried to resolve this by changing the reactor’s top-bed catalyst but the problem persisted.

The pressure drop issue was resolved by retrofitting the reactor with a Shell filter tray and a top-bed grading system, as shown in Figure 15.

![FIGURE 15: In cycles 1 and 2, the reactor suffered rapid increases in pressure drop, but in Cycle 3 (the first after Shell filter trays were installed), the pressure drop increased much more slowly.](image2)
8. UNLOCKING ADDITIONAL VALUE WITH SHELL REACTOR INTERNALS

8.1 The Shell reactor internals portfolio

In addition to fouling abatement hardware, Shell Global Solutions provides a wide range of other reactor internals designed to help you get the most out of your reactor. Shell’s reactor internals portfolio includes:

- **Shell HD trays** that help to optimise catalyst utilisation by achieving enhanced vapour–liquid and thermal distribution. Shell HD trays are extremely efficient and can be applied in a wide range of operations. They utilise nearly 100% of the catalyst inventory and offer high feed rate flexibility: they are applied in processes with high to very low gas loads.

- **Shell ultra-flat quench (UFQ) interbed internals**, which provide uniform quench mixing and separate phases mixing between catalyst beds;

- **Shell bottom baskets**, which offer a flat yet robust design to maximise the volume of catalyst that can be loaded in the bottom dome and avoid catalyst migration to the downstream equipments; and

- **Shell catalyst support grids**, which consist of V wire screens supported by two to four support beams for maximum robustness. These grids also help to avoid catalyst migration to the bed below.

These technologies can generate substantial margin increases for your operations because they:

- take up less space than conventional hardware, thereby helping to maximise reactor volume utilisation for increased catalyst volume and run length (Figure 16);

- significantly improve liquid–gas and thermal distribution under a wide range of operating conditions to use nearly 100% of the loaded catalyst and provide safe operation; and

- have a boltless, weldless and ergonomic design offering fast and safe installation, and easy maintenance, for shorter turnaround times.

**FIGURE 16**: The Shell reactor internals portfolio offers the opportunity to combine beds, as it provides enhanced liquid–gas and thermal distribution throughout the bed. In addition to the reduced space occupied by Shell reactor internals compared with conventional reactor internals hardware, this enables an increase in the volume of catalyst that can be loaded into the reactor combined with improved catalyst utilisation.
When installing Shell reactor internals, there are often opportunities to generate additional margin. For instance, depending on the axial temperature gradient, it might be possible to combine beds and thus, by eliminating interbed space, to increase catalyst capacity. Similarly, because Shell reactor internals are all designed to occupy minimal reactor volume, they enable the catalyst load per bed in the reactor to be maximised. This can be used to help:
- extend the cycle length;
- lower the weighted average bed temperature;
- increase throughput;
- process heavier and less-expensive feeds for higher margins; and
- improve yields for better economics.

Often, the outcome of using Shell internals is a combination of the above benefits, which results in significant margin improvements.

In addition, because Shell reactor internals are designed for fast bed access during catalyst change-outs, they can help to reduce turnaround times, thereby increasing plant availability, which can be worth significant revenue. Because the assembly and disassembly of Shell reactor internals do not require cutting or welding, catalyst change-outs and maintenance activities are safer and offer shorter working times in confined spaces compared with other internals. In some cases, inert entry to access the catalyst beds is not required.

8.2. Value estimates: What new Shell reactor internals could be worth to you as an operator

Some of the potential benefits of installing state-of-the-art reactor internals are quantified below. It is imperative that there is no fouling; if there is, the benefits could be severely curtailed.

a. Increased cycle life
Shell reactor internals may enable fewer interim shutdowns between major turnarounds. The potential value for a 100t/h unit that has a total shutdown time of 14 days is, therefore, $670,000.¹

b. Processing higher-margin feeds
Increased catalyst utilisation enables increased feed severity while achieving the same cycle length. The potential value of increasing the proportion of light cycle oil by just 5% in a 100t/h unit is some $2.2 million per year.²

c. Improved product quality
Installing Shell reactor internals can help to improve most product properties, including cetane, density, cold flow and viscosity index, through increased effective catalyst utilisation.

d. Better hydrocracker product yields
Shell reactor internals may enable a higher selectivity catalyst to be installed to produce higher volumes of valuable middle distillates. The potential value for a 200t/h unit is about $3.5 million per year.³

e. Shorter turnaround times
Shell reactor internals can typically save two days per turnaround, as they are designed by an operator for easy access and fast removal and installation. The potential value for a 100t/h unit is, therefore, $96,000 per turnaround.¹

f. Enhanced safety
Shell designs its reactor internals from an operator’s perspective, which results in hardware that is simple and does not require cutting and welding. Power tools, welding equipment and hot-work permits are, therefore, not required. In addition, manways are also made to be as large as possible to enable fast entry and exit, and relatively easy removal of personnel in the case of an emergency.

¹ Upgrade margin of $20/t in a typical diesel hydrotreater
² Light cycle oil upgrade margin is $50/t more than the gas oil upgrade margin
³ $100/t naphtha–diesel spread in a typical hydrocracker
9. WHY CHOOSE SHELL?

Shell Global Solutions’ technologies and services are delivered by an operator to an operator.

Shell is an owner–operator
As well as being an oil and gas technology licensor, the Shell Group also operates its own plants, so the operational feedback it receives from these assets helps to provide special insights into the challenges that its customers are facing. We also ensure that we incorporate the lessons learned from these plants into our design practices.

Track record
Shell’s reactor internals have been installed in more than 1,500 reactors and have been subjected to continuous improvement, informed by operational feedback and research and development, since they were first created over 25 years ago. In addition, Shell has designed more than 500 hydroprocessing units, more than 400 of which are on-stream.

Catalyst company affiliations
Shell Global Solutions works closely with its affiliated catalyst company, Criterion: the world’s largest hydroprocessing catalyst supplier and one that has a track record of over 50 years. Its association with Criterion opens the way for genuinely integrated and customised solutions comprising process technology, reactor internals and catalysts.

Continuous improvement based on real-world data
After designing, delivering and installing internals, Shell Global Solutions monitors their performance in these real-world situations and challenges itself to improve their design. Shell has been enhancing its reactor internals in this way since designing the first generation in 1988. Consequently, new clients are accessing reactor internals that have been subjected to continuous improvement and ongoing innovation for over a quarter of a century.

Experience
Shell Global Solutions has designed or revamped a large variety of different reactors. In addition to conventional hydroprocessing reactors in use at refineries worldwide and highly reactive feed petrochemical applications such as C\textsubscript{7}/C\textsubscript{8} and pyrolysis gas hydrogenation, these reactors range from 0.3-m-diameter vessels through to the giant, 1,200-t heavy paraffin conversion reactors used at Shell’s world-scale Pearl gas-to-liquids plant in Qatar. Shell’s leading experience in reactor internal design has been demonstrated many times, for example, when successfully installing reactor internals in reactors without support rings. In the field of reactor internal design, experience can be a precursor to added value.

Customised solutions
Shell Global Solutions does not just sell steel; it draws on its operating experience to provide customers with customised working solutions. These add substantially more value than hardware-only solutions because they are tailored to an operator’s specific situation and designed to help the operator achieve its objectives.
10. KEY TAKEAWAYS

IS FOULING LIMITING YOUR PERFORMANCE?

Refiners can substantially improve the profitability of their hydroprocessing reactors by installing latest-generation distribution trays and interbed internals. However, preventing foulants from reaching those trays and internals is imperative, as fouling can dramatically curtail their performance.

Fouling is one of the key issues affecting the performance of hydroprocessing reactors. It can lead to:
- short run lengths;
- unplanned downtime;
- unused catalyst activity;
- increased maintenance; and
- lost revenue.

IDENTIFY THE ROOT CAUSE AND DEVISE SOLUTIONS

Understanding the origin and characteristics of fouling is essential to tackling the problem. Shell Global Solutions has developed a three-tiered approach to fouling abatement that can help to:
- identify the root cause of the fouling using proven sampling techniques such as Shell BedCore;
- devise solutions outside the reactor, including feed filters and guard reactors; and
- devise solutions inside the reactor, including optimised bed-grading solutions and proprietary hardware, such as Shell filter trays, Shell filter and sedimentation trays, and Shell scale-catching trays.

TRANSFORM YOUR REFINERY ECONOMICS

With fouling problems resolved, you can capture the full value from the rest of the Shell reactor internals portfolio, which can help you to:
- increase cycle life;
- process higher-margin feeds;
- improve product quality;
- improve product yields;
- reduce turnaround times; and
- enhance safety.

Shell reactor internals have over 25 years of operational experience and have been installed in more than 1,500 reactor vessels across the world, of which about 80% are in non-Shell-operated refineries.
THE AUTHOR
Julien Sigaud is a Senior Hydrotreating Technologist at Shell Global Solutions International BV. He is responsible for the design of Shell reactor internals, providing support to customers having issues with the operability of their reactors and supporting Shell’s reactor internals licensing business.

Julien began his career with Shell in 2014 at the Shell Technology Centre Amsterdam, the Netherlands. Previously, he worked for AXENS and acquired expertise in aromatic complexes as project coordinator and manager.

Julien has a master’s degree in chemical engineering from the École nationale supérieure de chimie de Paris and a postgraduate diploma in organic chemistry and a master’s degree in petrochemicals, polymers and plastics from the IFP School, Paris.

ABOUT US
Shell Global Solutions provides technical consultancy and licensed technologies for the Shell Group and third-party customers within the energy industry. Shell Global Solutions strives to deliver innovative technical solutions and effective technology to support its customers in their day-to-day operations and delivery of strategic plans to improve the capacity and performance of existing units; integrate new process units into existing refineries and petrochemical complexes; incorporate advanced proprietary catalyst systems (Criterion) and reactor internals; through to the design of grassroots refineries.

Shell Global Solutions is affiliated with Shell’s catalyst companies, which innovate and sell catalysts through a network that includes Criterion Catalysts & Technologies, Zeolyst International, CRI Catalyst Company and CRI Leuna (formerly known as Kataleuna).

For further information, please visit our website at www.shell.com/globalsolutions.
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