Converting low-value feed to high-value products—CLG Hydroprocessing technologies and catalysts
Technology Innovations Introduced Through The Years

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Helping Refiners Find the Right Processing Schemes for Cleaner Products

The toughest challenge facing refiners today is how to optimize the production of cleaner products from a broad range of feeds. We speak from experience. We have designed thousands of projects in 70+ countries.

Refiners choose our technologies because they deliver higher conversion to lighter products and have fewer operating problems, regardless of feed quality. Why? Because every project is tailored for optimizing the refiner’s desired product slate from a given feedstock. Plus, from day one, every project is supported by a diverse technical team largely comprised of people who have decades of hands-on, day-to-day operating experience in refineries around the world.

We have designed thousands of projects in 70+ countries. More than half of the world’s hydroprocessing capacity uses CLG technologies.
Chevron, a leading refiner and innovator of hydrotreating technologies, combined resources with Lummus Technology, a leading technology and engineering company, and formed Chevron Lummus Global (CLG). CLG has a depth of experience in designing, building and operating hydrotreating units unmatched in the industry. Today, we offer a full suite of technologies and catalysts designed for optimizing production of the cleanest products from all types of feeds.

- **Clean transportation fuels**
- Ultra-low sulfur diesel (<10 ppm)
- Ultra-low sulfur naphtha (<0.5 ppm)

- **Low sulfur fuel oil (0.3% - 0.5%)**
- 
  - RFCC feed (3-6 MCR, 5-15 ppm V & Ni)
  - Coker feed

- **Group II/III base oils**
  - High purity
  - Practically zero sulfur
  - Ultra-low aromatics

- **Clean transportation fuels**
  - Ultra-low sulfur diesel (5 ppm, 55-70 cetane)
  - High smoke point jet (25-30 mm)
  - Ultra-low sulfur naphtha (0.0-5 ppm)
  - FCC feed
  - Waxy lube feed

- **Guard reactor for dirtier feeds**

- **Fuels**
  - FCC feed

- **Synthetic crude**
  - Mayan
  - Middle Eastern
  - Russian Export/Urals
  - Alaskan North Slope
  - West African
  - Venezuelan
  - Heavy Canadian
  - Oil Sands

- **Clean transportation fuels**
  - Ultra-low sulfur diesel (1 ppm)
  - Clean transportation fuels
  - Ultra-low sulfur diesel (1 ppm)

- **Clean transportation fuels**
  - Ultra-low sulfur diesel (5 ppm, 55-70 cetane)
  - High smoke point jet (25-30 mm)
  - Ultra-low sulfur naphtha (0.0-5 ppm)
  - FCC feed
  - Waxy lube feed
Over the last decade, nearly 80% of all refiners chose CLG’s residuum hydroprocessing technologies to convert difficult feeds to clean, low sulfur products.

In every project, CLG assesses the objectives and tailors the technologies and catalysts to fit the unique processing requirements of converting a given crude source into the desired product slate.

**LC-FINING** is well-suited for hydrocracking extra-heavy residuum, bitumen and vacuum residuum feedstocks into low sulfur products.

**RDS** removes sulfur, nitrogen and metals from residuum, producing clean RFCC feedstocks for conversion into clean fuels and base oils.

**UFR and OCR** guard-bed technologies enable refiners to increase feed throughput and/or process heavier feeds with higher levels of contaminant metals while maintaining excellent product qualities.

CLG offers a family of residuum conversion technologies and catalysts that can be tailored to help refiners optimize product quality, product yield, run length, capital investment and operating costs:

Bottom-of-the barrel? Convert it to a profit center.
LC-FINING
Ebullating Bed Process

Efficiently hydrocracks extra-heavy residuum, bitumen and vacuum residuum feedstocks to high-quality transportation fuels and fuel oils CLG’s ebullating bed process, LC-FINING, provides high distillate product yields while concurrently removing metals, sulfur, Conradson Carbon Residuum (CCR) and asphaltenes from difficult feedstocks. Only CLG’s LC-FINING process reduces both capital investment and operating expenses when upgrading to produce cleaner products from difficult feeds. Its integrated onstream catalyst addition and withdrawal system eliminates the need to shut down for catalyst replacements. The catalyst, and its addition rate, are customized for optimally converting the refinery’s crude source into the desired product slate. The proprietary hydrogen recovery system is tailored to be either low or high pressure depending upon the refinery’s economics. The low-pressure recovery system eliminates most of the high-pressure equipment required downstream of the reactors in other processes, while the high-pressure recovery system reduces power consumption by 0.25 hp/bbl. In every project, equipment pricing versus utility savings is evaluated so that production of the desired product slate is optimized. When LC-FINING is integrated with coking and deasphalting, distillate liquid yields as high as 92% can be achieved.

Advantages of LC-FINING:

- Ability to handle most difficult feeds with metals content up to 600 ppm
- Higher conversion of residuum to lighter distillates
- Can be integrated with hydrotreating and hydrocracking on same processing platform
- Higher reliability
- Can run continuously for 4 years
- Lower catalyst consumption
- Lower operating costs

Shell Canada generates higher revenue at its Scotford upgrader with CLG’s LC-FINING technology.

CLG’s LC-FINING process efficiently hydrocracks residuum and other low-quality feeds producing upgraded fuel oil and transportation fuels. It also triples the value of bitumen from oil sands by producing high-quality synthetic crude oil.

The adult Emperor Penguin stands up to 48 in. (122 cm) tall and can weigh from 50-100 lbs (22-45 kg). Highly adapted to their harsh Antarctic environment, penguins have the highest feather density of any bird, can drink saltwater, and dive to depths of 1,500-1,600 ft (450-500 m) without risk of barotrauma or decompression sickness. With no land predators, penguins have no fear of humans and will approach to within 10 ft (3 m) without hesitation.

Mayan
Middle Eastern
Russian Export/Urals
Venezuelan
Heavy Canadian
Oil Sands
LC-FINING hydrocracks the most difficult feeds.
How LC-FINING Works

The LC-FINING ebullating-bed process efficiently converts petroleum bottoms and other heavy hydrocarbons into high-quality fuel oils, or prepares them for more efficient conversion into ultra-low sulfur distillate products.

Feed from extra-heavy residuum, deasphalted oil or bitumen from oil sands is mixed with hydrogen and reacted with catalyst in an ebullating bed reactor. The back mixing in the ebullated bed reactor produces an efficient isothermal operation, eliminating the need for quenches within the reactor. Product quality is maintained at a consistently high level because fresh catalyst is intermittently added and spent catalyst removed while the reactor is onstream.

Reactor products flow to the high-pressure separator, low-pressure separator and then to product fractionation. Recycled hydrogen is separated and purified. Depending on refinery economics, the commercially proven low-pressure hydrogen recovery system can be utilized for purification of the recycle gas, which requires lower capital investment and allows design at lower gas rates.

Residuum product from the LC-FINING process can be used as fuel oil, synthetic crude or as feedstock to a coker or a solvent deasphalter. With conversion rates of 80% and higher, LC-FINING delivers high yields and high removal of contaminants in a safe, reliable, easy-to-operate plant at low investment.

Ultra-Low Sulfur Diesel and Gas Oil from the LC-FINING Process

LC-FINING technology can be easily integrated with distillate hydrotreating or hydrocracking processes to produce high-quality middle distillate products. Unlike coking, clean products can be produced without building an additional plant. By eliminating the need for additional downstream processing, refiners who choose LC-FINING have a more economical upgrade path for meeting the global demand for cleaner fuels. With more than 350,000 BPSD of difficult feed being converted to clean product using LC-FINING technology, its reliability is being proven day after day.

LC-FINING maximizes sulfur and metals removal.

565°C Conversion Range
- HDM: 60 - 80
- HDS: 85
Pre-treats residuum from heavy crudes for ultra-low sulfur fuel oil production and for RFCC conversion into high-quality, ultra-low sulfur transportation fuels

CLG’s fixed-bed residuum hydrotreating technologies, RDS for atmospheric residuum hydrotreating and VRDS for vacuum residuum desulfurization, provide a short, economical processing path for producing higher-value products from difficult feeds. Residuum Fluid Catalytic Cracking (RFCC) is the most popular processing route for the complete conversion of residuum oils. Without a pre-treating system in place, refiners must process atmospheric residuum from expensive crudes that are low in metals, carbon residuum and sulfur to avoid operating problems. Pre-treating RFCC feed with CLG’s hydrogen-efficient RDS/VRDS technologies sufficiently saturates even the most difficult feeds so that no further processing is necessary to produce high-value, light products.

CLG invented the technology in 1966. In the last 20 years, 90% of all fixed-bed residuum units have been licensed by CLG. Detailed operating data on feed and processing results have been collected and analyzed. With that information the reactor internals and catalyst systems have been continually refined and upgraded so that every unit is optimized for product quality, yield, run length, capital investment and operating costs.

Customized catalyst and superior internals extend operating cycles

After completing a thorough analysis of feed characteristics relative to operating kinetics and chemical reaction, CLG tailors the catalyst system for optimal performance. Every catalyst system is unique to the refiner’s particular need. As a result of a robust catalyst grading system and ISOMIX® internals, 12 months or longer cycle lengths are achieved while meeting targeted specifications for demetallization, desulfurization, carbon residuum reduction, denitrification and increased cracking conversion.

With a CLG RDS/VRDS residuum hydrotreating unit in the processing scheme, refiners have more flexibility in feed selection, achieve higher product yields and have fewer feed-related operating problems.

RDS/VRDS

Fixed-Bed Residuum Hydrotreating

Pre-treats residuum from heavy crudes for ultra-low sulfur fuel oil production and for RFCC conversion into high-quality, ultra-low sulfur transportation fuels

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RDS/VRDS technologies have successfully improved the efficiency of every type of RFCC unit in operation today.
UFR/OCR
Guard-Bed Technologies Economically Increase Capacity from RDS Units

UFR
CLG’s Upflow Reactor (UFR) process technology uses an upflow guard-bed reactor that is added to the processing scheme before the fixed-bed RDS reactors. It enables refiners to increase capacity, process heavier feeds or improve product quality from a fixed-bed RDS unit.

With a UFR in the processing scheme, refiners can increase feed throughput and/or process heavier feeds that have higher levels of contaminant metals while maintaining excellent product qualities. The UFR has lower pressure drop across the reactor than when a traditional down-flow, fixed-bed guard reactor is used. Consequently, capacity of the system can be increased by as much as 50%.

The principle advantages of the UFR are:
- Low pressure drop
- Prevention of guard-bed plugging problems thanks to the slightly expanded catalyst bed
- In case of RDS retrofits, no need to change out recycle gas compressors
- Opportunity to increase capacity as much as 50% in limited plot space
- Ability to add catalyst transfer system later
- Longer life of downstream fixed-bed catalyst

Plus, it provides refiners with the greatest flexibility if they want to process heavier feeds at a later date.

OCR
CLG’s Onstream Catalyst Replacement (OCR) process technology employs a countercurrent, moving-bed reactor. Like UFR, it enables refiners to significantly increase capacity or improve product quality from a fixed-bed RDS unit where a small fraction of spent OCR® catalyst is withdrawn and replaced with fresh OCR® catalyst on a weekly basis. When adding an OCR reactor in front of the RDS unit, refiners can increase feed throughput and/or process heavier feeds with higher levels of contaminant metals, while maintaining excellent product qualities and long fixed-bed run lengths. OCR enables refiners to process residuums with up to 400 ppm metals (Ni + V) or to achieve deeper desulfurization when processing low-metal feeds. In either case, the life of the downstream catalyst is improved substantially and problems from pressure drop buildup are reduced.

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Upflow Versus Downflow Reactors
With a UFR, refiners can process heavier feeds and/or earn higher margins.

OCR improves fixed-bed reactor volumes, particularly with high-metals residuum feedstocks.

From Heavy Feeds to High-Value Products Takes Just the Right Catalyst
Converting heavy feeds into high-value light products is a challenge for any processing scheme. CLG’s residuum technologies outperform the competition because the catalyst system is designed to maximize the refiner’s operating objectives. Working with Advanced Refining Technologies (ART), the catalyst joint venture of Chevron and Grace, CLG brings a level of processing customization knowledge unequaled in the industry. Together, ART and CLG have invested millions of dollars in technologies and catalysts that can maximize returns from the bottom-of-the-barrel. As a result, our licensees achieve greater conversion to lighter products and have fewer feed-related operating problems while processing heavier feeds.

OCR

The OCR can maintain high demetalization and desulfurization activity for as long as 3 to 4 years.

KNPC chose CLG’s UFR/RDS for the world’s largest residuum hydrotreater complex. KNPC designed its New Refinery Project to help improve the state’s environment while meeting the growing domestic need for power generation. To meet these objectives, they chose CLG’s UFR and RDS technologies to economically produce 250,000 BPSD of low-polluting, low sulfur fuel oil from Kuwait’s heavy crude.
ISOCRACKING
Processing Technology and Catalysts for Producing Clean Fuels and Ultra-Low Sulfur Diesel

CLG’s hydrocracking experience began with Chevron’s invention of modern hydrocracking more than 50 years ago. Since then, CLG and Chevron have spent hundreds of millions of dollars developing hydrocracking technologies and catalysts that optimize the production of cleaner fuels.

Nearly half of the world’s refiners are using CLG’s hydrocracking technology, ISOCRACKING, and are producing more than 2 million barrels a day of clean fuels. The lessons learned from completing more than 100 projects, with very diverse requirements, enable us to offer expertise in hydrocracking that few, if any, other companies can match. As a result, CLG licensees earn top Solomon ratings with high operating factors, unparalleled safety records and consistently reliable performance.

A clear upgrade path

Refiners today are finding that the increased demand for high-quality transportation fuels is forcing them to convert a higher percentage of crude oil to lighter products. For many, that means adding hydrocracking capacity to meet more stringent product specifications. To maintain profitability, it is essential that these quality improvements be made without sacrificing product yield.

CLG’s ISOCRACKING technology is the most flexible upgrade path to lighter products — a path that can help you reach a balance between stringent product specifications, product yield, cycle run length, capital investment and operating costs. CLG has helped refiners working with difficult feeds, such as heavy coker gas oils, deasphalted oils and material with a high end point (>1,000°F) to efficiently produce clean fuels.

Around the world, the allowable limit for sulfur in transportation fuels is moving lower. In California, where CLG’s headquarters are located, it went to 15 ppm in 2006. In Europe it went to 10 ppm in 2009. Through the years, CLG has repeatedly been the first to introduce technologies and catalysts that enable refiners to economically, safely and reliably meet tough new standards for cleaner transportation fuels.

About 88% of amphibian species are frogs. Frogs have been critical to science for centuries. Today biochemists are studying frog toxins for use as therapeutic drugs. Chemicals isolated from frog skin produce a painkiller 200 times more potent than morphine and have shown to be HIV resistant.
CLG Customizes the Processing Scheme and Catalyst Selection
So Refiners Can Maximize Profitability While Producing Clean Fuels

Every refiner has unique operating parameters. CLG’s experienced technical team works with each licensee to design a solution that maximizes that refiner’s benefit, and in the case of revamp designs, minimizes disruption to the existing refinery operations.

Single-Stage Once-Through (SSOT)
The SSOT configuration produces feedstocks with superior characteristics for FCC feeds, high-V.I. lubricant base stocks or ethylene plant feeds. It employs a moderately high-pressure design in conjunction with a tailored catalyst system that maximizes hydrodenitrogenation and produces high-hydrocracking activity. Because it uses only “moderate” pressure hydrocracking, the initial investment is lower. However, it provides a seamless upgrade path for economically revamping the process at a later date.

Single-Stage Recycle (SSREC)
SSREC incorporates a recycle stream and enables 100% conversion of lighter, high-quality feeds to clean products. Depending on the type of feed and desired product slate balance, SSREC can be an economical upgrade path for increasing yields of cleaner products. The SSREC is also an efficient option for processing heavy feeds in low-capacity units.

Two-Stage Recycle (TSR)
CLG’s TSR reactor is designed for optimizing high-capacity plants. For plant capacities exceeding 40,000 BPSD, TSR requires a smaller investment than a Single-Stage Recycle (SSREC) configuration. With TSR, refiners can process a wider range of feeds and feed rates.

Novel Configurations - Building Blocks for the Future
CLG has commercialized a series of process innovations that lower investment and operating costs, including:

- **ISOCRACKING with Integrated Hydrotreating** - It can save about 30% of the investment cost of a stand-alone hydrotreater.
- **Optimized Partial Conversion (OPC)** - It reduces the investment cost for a partial conversion unit with difficult-to-process feeds and is also ideal for revamps.
- **Reverse-Stage ISOCRACKING** - It allows full conversion while lowering energy and investment costs.
ISOMIX® Inside
High-Performance Reactor Internals Provide Uniform Distribution and Prevent Hot Spots

With CLG’s ISOMIX® reactor internals for fixed-bed hydroprocessing reactors, refiners can maximize catalyst utilization from high-activity catalysts and improve clean-product yields from more difficult feeds.

ISOMIX® internals consist of ISOMIX® nozzles for flow distribution and the ISOMIX® mixing box. The ISOMIX® mixing box provides thorough inter-bed mixing and quenching which prevents propagation of temperature maldistribution from bed to bed. This minimizes hot spots and provides better operating control.

The ISOMIX® flow nozzles uniformly distribute gas and liquid to the catalyst bed providing good gas-liquid mixing and heat exchange. Given the even flow, over a range of flow rates, the performance is less affected by distributor tray out-of-levelness. Plus, the spray pattern produced minimizes the catalyst depth needed for uniform and complete wetting. Consequently, there is greater catalyst utilization and higher reactor volume efficiency.

ISOMIX® internals have been used in reactors as large as 15 ft (4.6 m) in diameter and have proven to be highly safe and reliable. They take less reactor space, extend catalyst life and increase yields over other internals.

ISOTREATING
Refineries Can Convert Up to 99% of Straight-Run and Cracked Feeds to Ultra-Clean Diesel and Kerosene

The function of the ISOTREATING process is the removal of sulfur and other contaminants (such as nickel and vanadium) from the feed, and to saturate molecules, so refiners can transform more difficult feeds into higher-value products. Highly flexible, the ISOTREATING process can be added either downstream from a residuum hydroprocessing unit, such as LC-FINING, or integrated with any hydrocracking processing scheme to improve product quality and yield.

With more than 10 units in operation it has been demonstrated that integrating a reactor for ISOTREATING requires 40% lower investment to achieve a given processing objective. The reaction section requires 50% fewer pieces than that of a stand-alone unit. Additionally, when processing feed from an LC-FINING unit, the hydrotreating reactors share the same high-pressure hydrogen loop, utilizing the excess hydrogen remaining in the LC-FINING effluent. The success of the ISOTREATING process is a combination of science and experience. Every processing scheme is unique, so, based on its experience, CLG customizes the catalyst selection and layering in the reactor to optimize production of the desired product slate.

As a result, CLG has enabled refiners to upgrade heavy refractory feeds into high-value products with minimal capital expense and operating costs.

ISOCRACKING
With the demand for cleaner and cleaner fuels growing rapidly, proper catalyst selection is more important than ever. With more than 50 years of experience developing both hydrocracking catalysts and technologies, we have learned that optimizing production is best achieved by layering one or more hydrodenitrification and hydrocracking catalysts and creating a catalyst system unique to the refiner’s operating environment and processing objectives. CLG designs layered (and even blended) catalyst systems because the feedstock changes chemical properties along the reaction pathway. With a layered/blended system, refiners achieve maximum conversion and throughput while meeting more stringent product quality specifications.

We start by assessing feedstock type, operating conditions, the desired product specifications, and unit operating objectives. That data is then compared to the information we have accumulated from our work with the operators of more than half of the hydrocracking units in operation today. Given the wide variety of feedstocks, processing conditions and tightening product specifications, there is seldom a perfect match, but our library of actual operating data is so large, we are able to complete analytical iterations with a high degree of confidence. CLG knows how to formulate and combine catalysts for optimum synergy between components. The end result is a catalyst system that optimizes the balance of cracking activity, hydrogenation activity, yield selectivity and catalyst life.

**Ongoing Catalyst Development**

The need to get more productivity, more flexibility and more profitability from the hydrocracking process is an ongoing challenge for refiners. CLG’s ISOCRACKING® catalyst development team has been addressing that challenge for more than 50 years. In the 60s, the focus was on the production of transportation fuels using amorphous catalysts. In the 80s, the portfolio was expanded to zeolitic catalysts for maximizing the production of naphtha and jet fuel. Since then, the investment in R&D and pilot plant facilities has continued to grow as CLG tackles the primary challenge of today, how to process the highest quality products from the broadest range of feed, without compromising yield or operating safety.

**Proven Performance from ISOCRACKING® Catalyst Systems**

The effectiveness of CLG’s tailored catalyst systems has been proven over and over again by improved hydrocracking performance. In general, ISOCRACKING® catalysts deliver:

- Diesel fuel with a very high cetane number and low pour point even from poor-quality feeds
- Kerosene with low freezing points and high smoke points — optimum fuel combustion characteristics
- Greater flexibility in processing a wider range of feeds from different crudes

**Technical Expertise with You Every Step of the Way**

In addition to providing tailored catalyst solutions, CLG also provides tailored technical support. During the critical catalyst loading process, CLG provides a team of technical experts who have hands-on experience in refinery operations around the world. They help get your hydrocrackers onstream quickly, and will help keep them running at peak efficiency with comprehensive support programs that provide the technical information and assistance you need — before, during and after catalyst loading. Proper catalyst loading is critical to optimizing performance.
The world of base oil manufacturing was revolutionized when CLG introduced ISODEWAXING technology and catalysts in 1993. Environmental and regulatory groups were demanding cleaner-burning, more fuel-efficient engines, but engine manufacturers were constrained by insufficient capacity of high-quality lubricants that could produce the required performance.

Manufacturing vehicles with improved engine performance requires widespread availability of millions of gallons of low-volatility, low-viscosity lubricants. CLG’s ISODEWAXING technology and catalysts made this possible, and, in the process, improved manufacturing operations and ROI for refiners.

High-quality lubricants require high-quality base stocks. Producing high-quality base stocks requires chemically transforming undesirable compounds in the feed. Prior to the introduction of the ISODEWAXING technology, solvent processing was used to remove the undesirable compounds. Many impurities were left in the oil. Alternatively, ISODEWAXING technology catalytically transforms waxy feed molecules into highly stable base oil molecules that can be tailored to meet the needs of almost any lubricant application.

These molecules have high V.I., low-pour points and excellent resistance to oxidation. Further, because the ISODEWAXING process preserves the base oil’s paraffinity, it can produce higher product V.I. and/or higher yields than other dewaxing processes. Today, more than 60% of the world’s premium base oil is produced using CLG’s technology. Those base oils are being used worldwide to produce lubricants that meet stringent performance specifications including:

- Lighter viscosity grades for increased fuel economy,
- Lower volatility for reduced oil consumption and oil thickening,
- Improved oxidation and thermal stability for longer drain intervals, and
- Improved lubricant performance at low and high temperatures to meet the needs of modern engine designs.
CLG’s Experience is Your Opportunity

CLG’s technical team can help refiners optimize production of premium base oils from a broad range of feeds including vacuum gas oil (VGO); refinery process streams such as hydrocrackate or deasphalted oil (DAO), raffinates, foots oil and slack wax produced in existing solvent base oil facilities; or other waxes. Even feeds with close to 100% wax, such as slack wax, hard wax and Fischer-Tropsch derived wax, can be converted to high-value premium base oils in a once-through process without recycling unconverted wax. Using ISODEWAXING technology base oils with V.I. ranging from 95 to 140 and higher can be produced from any of these feeds. Pour points may range from low (-9 to -15°C) to ultra-low (<-40°C).

CLG’s three-step, all-hydroprocessing scheme includes: ISOCRACKING technology (or ISOTREATING if processing solvent-extracted raffinates) to remove impurities, increase V.I. and improve thermal and UV stability; ISODEWAXING technology to reduce pour point; and ISOFINISHING technology to improve oxidation stability and color.

The World is Moving to All-Hydroprocessing

In response to increased capacity of high-quality base oils, automotive OEM’s are rewriting performance specifications. CLG’s all-hydroprocessing technology leads the way for meeting these new specifications, and is recognized worldwide for operational flexibility and superior product qualities.

The result has been a worldwide network of hydrosprocessing-based refineries with high operating factors, unparalleled safety records and a history of reliable performance.

EXPERIENCE THE DIFFERENCE

CLG is the only licensor of hydrosprocessing technologies that is experienced as both a refiner and world-class engineering company. Most of our staff have had hands-on operating experience with Chevron, one of the largest refiners in the United States. Our expertise extends to every phase of high-pressure hydrosprocessing and we make it available to you through individualized service and a worldwide technical support network that is second to none.

When you choose CLG as your technology licensor, you gain access to a breadth of experience that started with the invention of modern hydrosprocessing and expanded to include upgrading most of the world’s hydrosprocessing-based refineries so they could optimize the production of cleaner products.

From day one, CLG provides an experienced team of research, development and process engineers offering technical information and assistance including:

- Pilot plant studies
- Design follow-up
- Operator training
- Startup assistance
- On-site technical support
- Users’ seminars
- Technology updates
- Catalyst regeneration and disposal consultation
- New product development and improvement
- Equipment evaluation
- Plant modification/optimization
- Debottlenecking assistance
- Procedures development
- Technology symposia
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Lube Yield Comparison – Hydrocracking/Dewaxing to Make 100 V.I. Base Oil

<table>
<thead>
<tr>
<th>Hydrocracker feed rate, BPD</th>
<th>Hydrocracker wax base oil yield %</th>
<th>Dewaxer feed rate, BPD</th>
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<th>Base oil yields, BPD</th>
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<tr>
<td>Catalytic dewaxing</td>
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Using all-new ISODEWAXING® catalyst to make premium base oils allows the refiner to lower processing severity in the hydrocracker and substantially increase yields.
Butterflies are notable for their metamorphosis from larval caterpillar, to inactive pupal, and then into one of nature’s most beautiful creatures.

CLG has spent more than 50 years developing refining technologies, catalysts and processes that enable refiners to transform the most difficult crude oils into the cleanest, safest products possible. We continue to invest millions of dollars annually in research on ways to do it better. Working together we can help protect the environment around us.