K-PRO™

KBR Propane Dehydrogenation (PDH)Technology for On-Purpose Propylene Production

K-PRO™ ADVANTAGES

KBR's latest offering, K-PRO provides innovative technology grounded in leading expertise and deep experience in order to maximize propylene production, while offering the following advantages:

- Lowest total cost of ownership
- Commercially proven technology based on K-COT and KBR's extended experience in FCC reactor design
- Safe, reliable, and robust operation with high on-stream factor
- Innovative non-precious metals and non-chromium containing catalyst
- High propane conversion and highest selectivity towards propylene
- High polymer grade propylene yields

Paradigm Shift in Propylene Production

KBR's Propane Dehydrogenation (PDH) technology, K-PRO™ is an engineering process and service based on its Catalytic Olefins Technology (K-COT™) which is a commercially proven technology for converting low-value olefinic, paraffinic or mixed streams into high-value propylene and ethylene. K-COT was built on KBR's experience in developing catalytic olefins technology for various types of feed.

KBR's Propane Dehydrogenation offering combines the know-how of K-COT with a novel, non-precious metals and non-chromium containing, high selectivity dehydrogenation catalyst. The technology can be implemented as a stand-alone propylene production unit independent of a steam cracker or an FCC unit. With K-COT and K-PRO, KBR offers technologies to meet market-driven propylene demand for both naphtha and propane feedstocks.

K-PRO signifies a paradigm shift in on-purpose propylene production. The winning combination of reliable and economically advantageous catalytic cracking technology with innovative catalyst outperforms competitive alternatives and sets new standards for OPEX and CAPEX.

Propylene Alternative

Most propylene worldwide is produced as a by-product from either steam crackers or FCC units. However, with the large number of new ethane-based steam crackers coming online in the next few years, the ongoing transition of many existing steam crackers from naphtha feedstock to ethane and propane feedstock, and with very few new FCC units being built, it is anticipated that these traditional sources of propylene supply will fall short of demand by 45 MMTPA in 2027.

K-PRO is a novel offering based on a commercially proven technology for the production of high-value propylene from low-cost propane.

K-PRO TECHNOLOGY FEATURES

K-PRO is a novel FCC-based technology for propane dehydrogenation using a patented low-cost, high-performance catalyst

- High propane conversion and highest selectivity towards propylene
- Produces polymer-grade propylene
- Low-cost and environmentally friendly catalyst (no Pt or Cr)
- Low emissions: reduced NO_x and CO_2 emissions
- Minimal catalyst losses and catalyst make-up
- Simple reactor design leads to simple operation
- Reliable operation and high on-stream factors
- Overall, lower CAPEX and OPEX compared to current PDH technologies, which leads to a lower cost of production

FEATURES

The reactor (converter) of K-PRO comprises four sections:

- **Riser/reactor,** where the PDH reaction takes place in the presence of catalyst
- **Disengager,** where catalyst is separated from product gas through the use of cyclones
- **Stripper,** where process gas contained in catalyst pores is removed via stripping with steam or nitrogen and routed with the product gas
- **Regenerator,** where coke formed on the catalyst during the PDH process is removed by combustion with oxygen, supplying heat of reaction for the PDH process

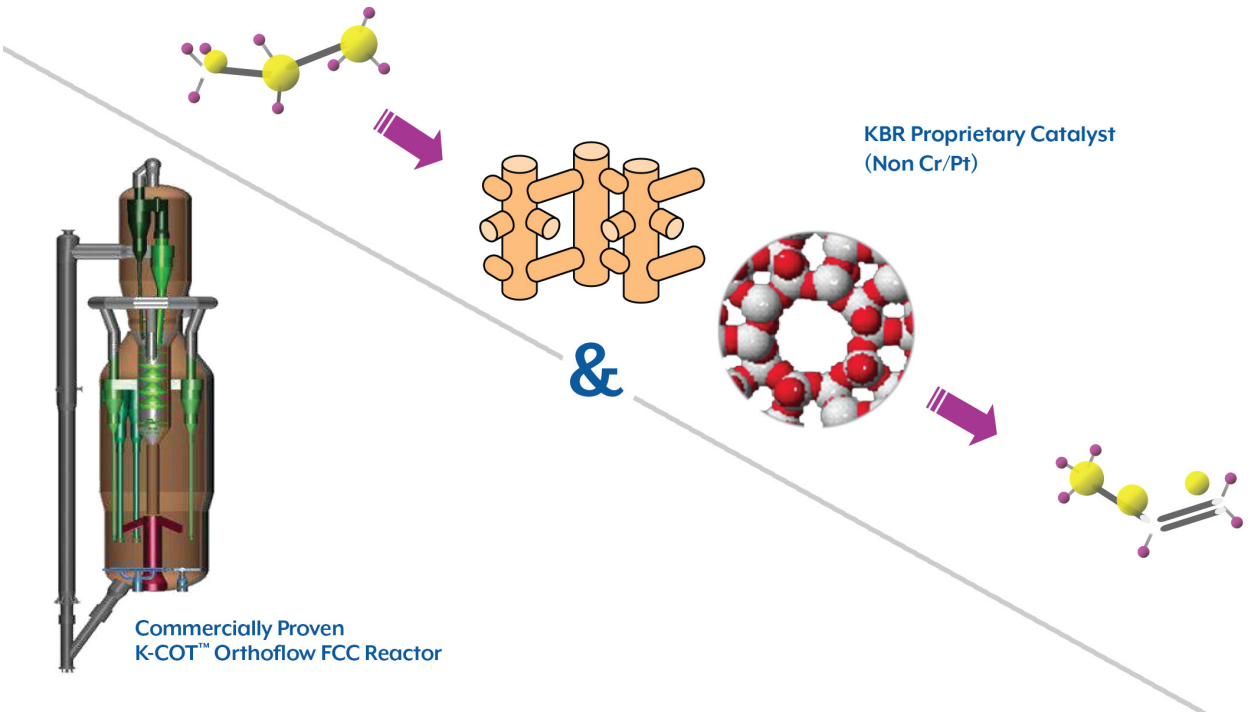
K-PRO REACTOR DESIGN

While the commercially proven K-COT™ reactor design is based on KBR's proprietary Orthoflow™ FCC technology, it features unique and innovative design aspects. These ensure that the petrochemical feeds in K-COT units or the propane feed in K-PRO units are much lighter than those typical to a traditional refinery FCC unit.

Heat Balance - The PDH process is endothermic and as such, fuel must be continuously imported into the reaction system to maintain heat balance. KBR's patented and commercially proven catalyst well along with a continuous fuel firing design is used in the catalyst regeneration section of the K-PRO reactor. The heat from the catalyst regeneration is directly transferred to the reaction section of the K-PRO reactor making the process very energy-efficient and stable.

Catalyst/Hydrocarbon Separation - The combination of the highly efficient cyclones and KBR's patented and commercially proven catalyst fines removal system removes catalyst fines that might carry over with the effluent cracked gas, thus achieving best possible catalyst/hydrocarbon separation.

Reaction Section - The K-PRO converter uses a customized riser/reactor design optimized for the unique requirements of the PDH process.

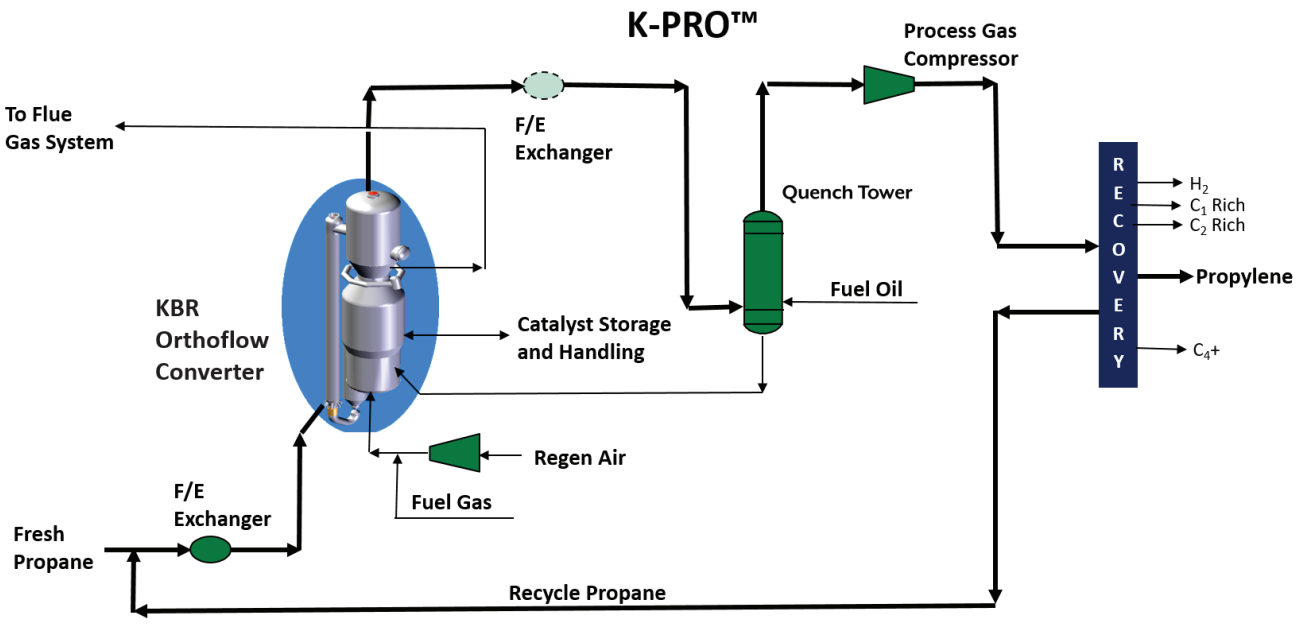


K-PRO Reactor Design. K-PRO = K-COT Reactor + Proprietary Catalyst

Recovery Section Design

K-PRO produces polymer-grade propylene. The product recovery flow scheme is optimized using KBR's extensive design experience in olefins recovery while taking into consideration client requirements and site-specific utility costs, ensuring:

- Lower capital investment
- Exceptional reliability and operability
- Efficient energy utilization
- High on-stream factor
- Wide turndown flexibility
- Smooth start-ups
- Lower maintenance costs
- Turnaround time of 5-6 years
- Lower propylene production cost
- Safe, environmentally compliant designs



The K-PRO design incorporates KBR's years of experience in designing innovative, efficient and cost-effective process units for olefins production.

Project/Client	Location	Capacity
JSEL	Pakistan	600KTA
Confidential	China	2 x 900KTA

K-PRO Licensees

ABOUT KBR, INC.

We deliver science, technology and engineering solutions to governments and companies around the world. KBR employs approximately 29,000 people worldwide with customers in more than 80 countries and operations in 40 countries.

KBR is proud to work with its customers across the globe to provide technology, value-added services, and long-term operations and maintenance services to ensure consistent delivery with predictable results.

At KBR, We Deliver.

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