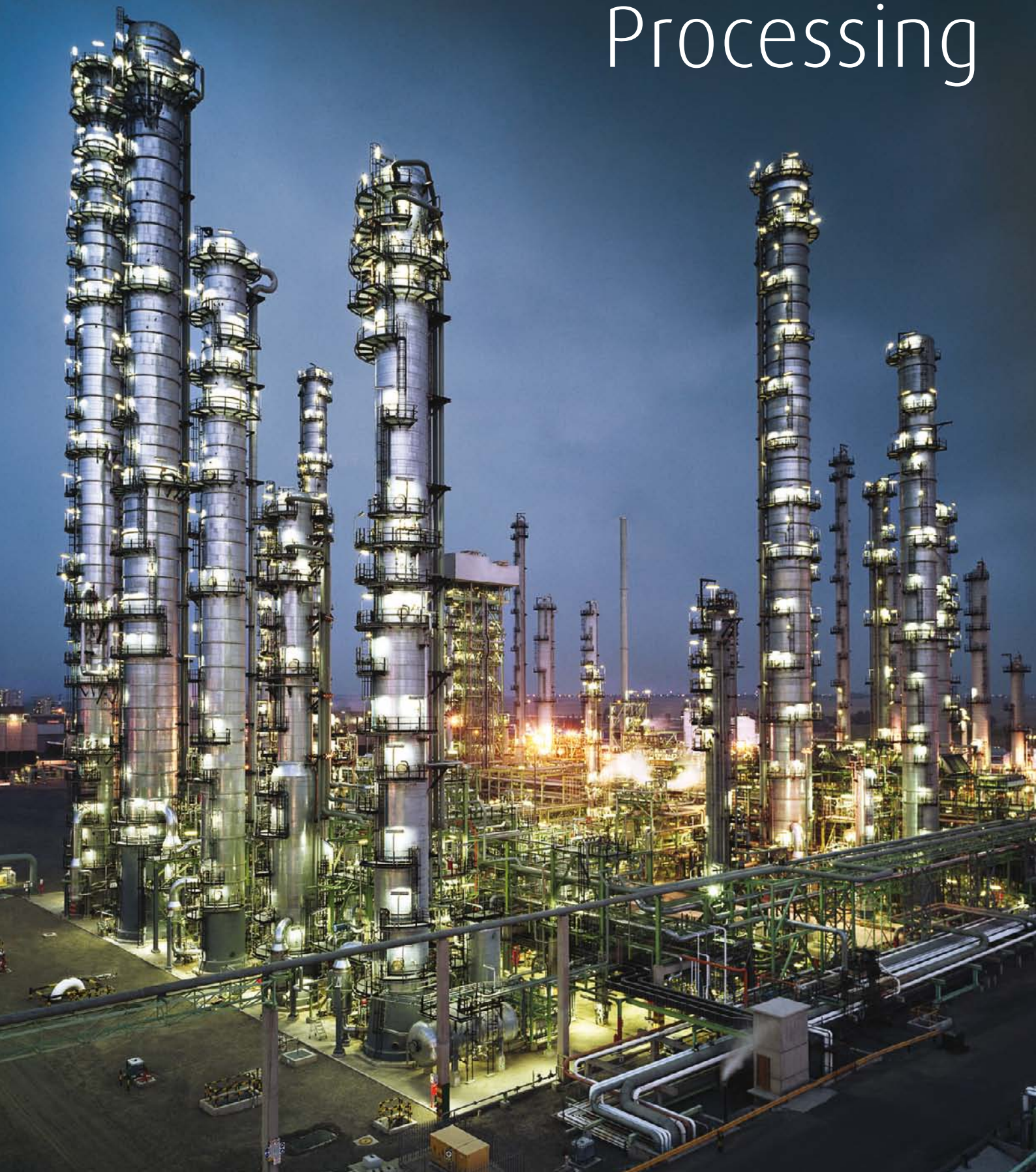


THE LINDE GROUP

Linde

Petrochemical Processing



Introduction.

About 80% of all petrochemicals are derived from products of ethylene plants, which are the heart of petrochemical complexes.

Today's modern ethylene plants are a complex network of more than 300 individual units, for thermal cracking, cracked gas compression and physical scrubbing, fractionation, adsorptive drying, catalytic hydrogenation and others, operating in the temperature range of 1,100°C to -170°C. Due to the complexity of the process only a few experienced contractors can offer competitive designs for ethylene plants today.

Ever since building the world's first ethylene plant in 1931 based on cryogenic separation of ethylene from coke oven gas, Linde has been incorporating the latest improvements and innovations in the design of each new plant. The high degree of creativity and the continuing success of Linde's capable engineering and design staff in applying new features for the optimum plant design has resulted in the construction of a large number of world-scale olefin plants in many different countries. Extensive

feedback of operating data and information on process and equipment performance in operating plants has provided Linde with substantial background for the yet more efficient design of future plants, and is the basis of Linde's world-wide accepted leading position in this technology.

More than 50 new plants have been built all over the world, with capacities up to 2 million MTA, for processing of all types of feedstocks.

Technology.

Outstanding process technology

Together with the proven furnace technology Linde offers a separation process which is based on a unique sequence with front-end hydrogenation and open loop heat pump driven C_2 splitter. These cornerstones of Linde's technology have been developed during 60 years in cryogenic separation of ethylene from gas mixtures. The separation technology of Linde is superior to other concepts and has been applied to improve the performance even in plants of competitive technologies. The outstanding features translate into lowest energy and feedstock consumption figures for all feedstocks in single train plants up to 1.5 million MTA ethylene capacity.

Due to the permanent improvement of Linde's technology, Linde can employ the latest technologies for revamps and capacity expansion of existing plants. Revamps offer advantages in investment costs per ton of ethylene, due to the fact that spare capacities of equipment and existing infrastructures can be used and only

the bottlenecks of a plant have to be replaced. Linde's engineering staff has developed special tools and methods for optimized solutions for plant revamps and capacity expansions, which are accepted by the industry as highly competitive with respect to technology and economics.

Feed flexibility

Linde can offer ethylene plants for all feedstocks, such as ethane, propane, butane, LPG, light naphtha, full range naphtha, raffinates, AGO, gas condensates and HVG0. AGO, gas condensates and HVG0 require special technology for feed vaporization in order to avoid unvaporized feedstock to enter the reaction section.

Most of Linde's latest plants offer a wide flexibility in feedstocks and products to the operator, in order to run the most economic feedstock scenario. Modern plants are processing up to 5 different external feed streams together with several internal recycle streams.

An attractive alternative for ethylene plants is the application of an acetylene recovery step instead of the acetylene hydrogenation normally used in ethylene plants. Linde's acetylene recovery is based on the extraction of acetylene with DMF, and is accepted by industry as the leading technology for acetylene recovery.

Cracking furnace technology

One essential element of the outstanding Linde ethylene process is the PYROCRACK® furnace technology. For all commercially used types of feedstock and economic scenarios optimal cracking furnaces can be offered with respect to selectivity towards ethylene and other valuable olefins and highest capacities per furnace. The PYROCRACK® furnace technology comprises all features of a modern furnace design, well known and approved in the industry as a robust design with an excellent availability.

Ethylene plant in Belgium





Furnaces in an ethylene plant in Saudi Arabia

Perfection.

Large single furnace capacities are designed with the Linde twin-cell firebox concept combined with a common convection section. Single furnace capacities up to 180,000 mta ethylene for liquid feeds and 260,000 mta for gas cracking are in operation or under construction, leaving still some room for a future increase. Modern twin-cell furnaces can be designed for individual cell decoking, an operation in which one cell remains in normal operation where as the other radiant cell is decoked.

Linde's PYROCRACK® coils have been used successfully in commercial cracking furnaces for gas and liquid cracking. Long run lengths are achieved with conservative maximum heat flux designs. Commercial experience for gas and liquid feedstocks in the short residence time range down to 0.15 seconds is an excellent basis for future projects. If required, PYROCRACK® furnaces are capable to process the full range from ethane through heavy gasoils and hydro-treated feedstocks with end boiling points close to 600 °C.

Turn-key perfection

With its long experience as turn-key contractor of petrochemical mega projects, Linde can offer the experience of a technology supplier and a first class worldwide EPC contractor in one hand, which translates into a single point responsibility in execution of projects.

Global alliances

In order to strengthen its position worldwide, Linde has entered into regional cooperations with engineering partners, known to be absolute leaders in certain areas of the world. A very successful cooperation is in place with Samsung Engineering of Korea for the Asian/Pacific market, which has led to contracts for 5 world-scale ethylene plants in China, Thailand, Malaysia, Saudi Arabia and India.

Today Linde is in a position to offer most competitive turn-key or convertible contracts to its clients, either alone or in very strong regional alliances with first class EPC contractors. However, besides turn-key responsibility, Linde can offer all kinds of services to the industry, including studies, front-end engineering, detail engineering, procurement and construction.

Based on the experience from a mega project of a gas terminal in Norway, Linde has gained tremendous experience in modularization of plant components and in project execution under extreme environmental conditions. This experience allows Linde to offer plants in all parts of the world, including areas with poor infrastructure.

Responsibility.

Major awards

The recent years consolidated Linde's position as the leading ethylene contractor world-wide. Of the plants awarded by competitive bidding Linde won more than 30% of the contracts in the last ten years.

Current executions of ethylene plants are in India (1.1 million MTA), China (1 million MTA), in Abu Dhabi (1.5 million MTA) and in Saudi Arabia (1 million MTA). The last has been executed ahead of schedule despite a difficult environment in Saudi Arabia.

Recently the capacity expansion of the BASF cracker in Antwerp to nearly twice the original capacity completed. With capacities of 1.1 million MTA ethylene and 600 000 MTA propylene this unit is currently the largest liquid cracker in the world.

With Borouge 2 Linde has built world's largest ethane cracker with a capacity of 1.45 million MTA of ethylene.

Environmental features

Linde plants can easily match any environmental requirement, some of them operate in densely populated areas with the highest environmental standards.

Practically all furnaces are furnished nowadays with LowNOx burners in order to meet the BAT (Best available technique) requirements. If required, a further reduction of NOx level to the range of 60 mg/mn³ and below can be achieved and guaranteed by the installation of a SCR DENOX-system.

For the treatment of spent caustic, Linde has proprietary technology available with proven performance in several plants world-wide.

To complete the environmental protection system of petrochemical plants, Linde provides incinerators for the thermal treatment of solid and liquid wastes. They are of proprietary design and achieve the most stringent requirements.

Down-stream processes

More than 50 % of the ethylene product is consumed in polymer processes for the production of HDPE, LDPE and LLDPE. Consequently Linde offers the EPC services for these technologies as well. For the Unipol process Linde is one of the nominated bidding contractors. Two world scale PE plants for Sharq in Al Jubail/Saudi Arabia are under execution.

Recently Linde has won a contract for a PP plant in Tobolsk (CIS) based on Ineos PP technology.

Another important down stream process is the production of linear alpha olefins, used as co-polymers and for the production of alpha alcohols, synthetic lubricants, etc. with an increasing economic importance. Since many years, Linde has supplied plants for the recovery of these hydrocarbons and since a few years Linde has offered the complete plants, based on the new alpha-SABLIN® process, developed in cooperation with Sabic. The first large scale plant with a capacity of 150,000 mta alpha olefins went on-stream in 2006 operated by United in Al Jubail/Saudi Arabia.

Borouge 2, world's largest ethane cracker



Summary.

Linde can offer various processes to the petrochemical industry in all kinds of contract forms. Long experience in project management and as a general contractor in several mega projects have contributed to an extensive engineering and project execution know-how, which qualifies Linde as one of the top addresses in international plant construction. Regional alliances with strong partners will contribute in the future to improve Linde's record in areas, where local partnership is mandatory to be competitive.



Polyethylene plant in the Czech Republic

Collaborate. Innovate. Deliver.

Linde's Engineering Division is a leading player in the international plant engineering business. Across the globe, we have delivered more than 4,000 plants and cover every step in the design, project management and construction of turnkey industrial facilities. Our proven process and technology know-how plays an indispensable role in the success of our customers across multiple industries – from crude oil, natural gas extraction and refining to chemical and metal processing.

At Linde, we value trusted, lasting business relationships with our customers. We listen carefully and collaborate closely with you to meet your needs. This connection inspires us to develop innovative process technologies and equipment at our high-tech R&D centres, labs and pilot plants – designed in close collaboration with our strategic partners and delivered with passion by our employees working in more than 100 countries worldwide.

From the desert to the Arctic, from small- to world-scale, from standardised to customised builds, our specialists develop plant solutions that operate reliably and cost-effectively under all conditions. You can always rely on us to deliver the solutions and services that best fit your needs – anywhere in the world.

Discover how we can contribute to your success at www.linde-engineering.com

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Core competencies at a glance

Plant engineering

- Air separation plants
- LNG and natural gas processing plants
- Petrochemical plants
- Hydrogen and synthesis gas plants
- Adsorption plants
- Cryogenic plants
- Carbon capture and utilisation plants
- Furnaces, fired heaters, incinerators

Component manufacturing

- Coldboxes and modules
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic columns
- Cryogenic storage tanks
- Liquefied helium tanks and containers
- Air-heated vaporisers
- Water bath vaporisers
- Spiral-welded aluminium pipes

Services

- Revamps and plant modifications
- Plant relocations
- Spare parts
- Operational support, troubleshooting and immediate repairs
- Long-term service contracts
- Expert reviews for plants, operations and spare part inventory
- Operator training