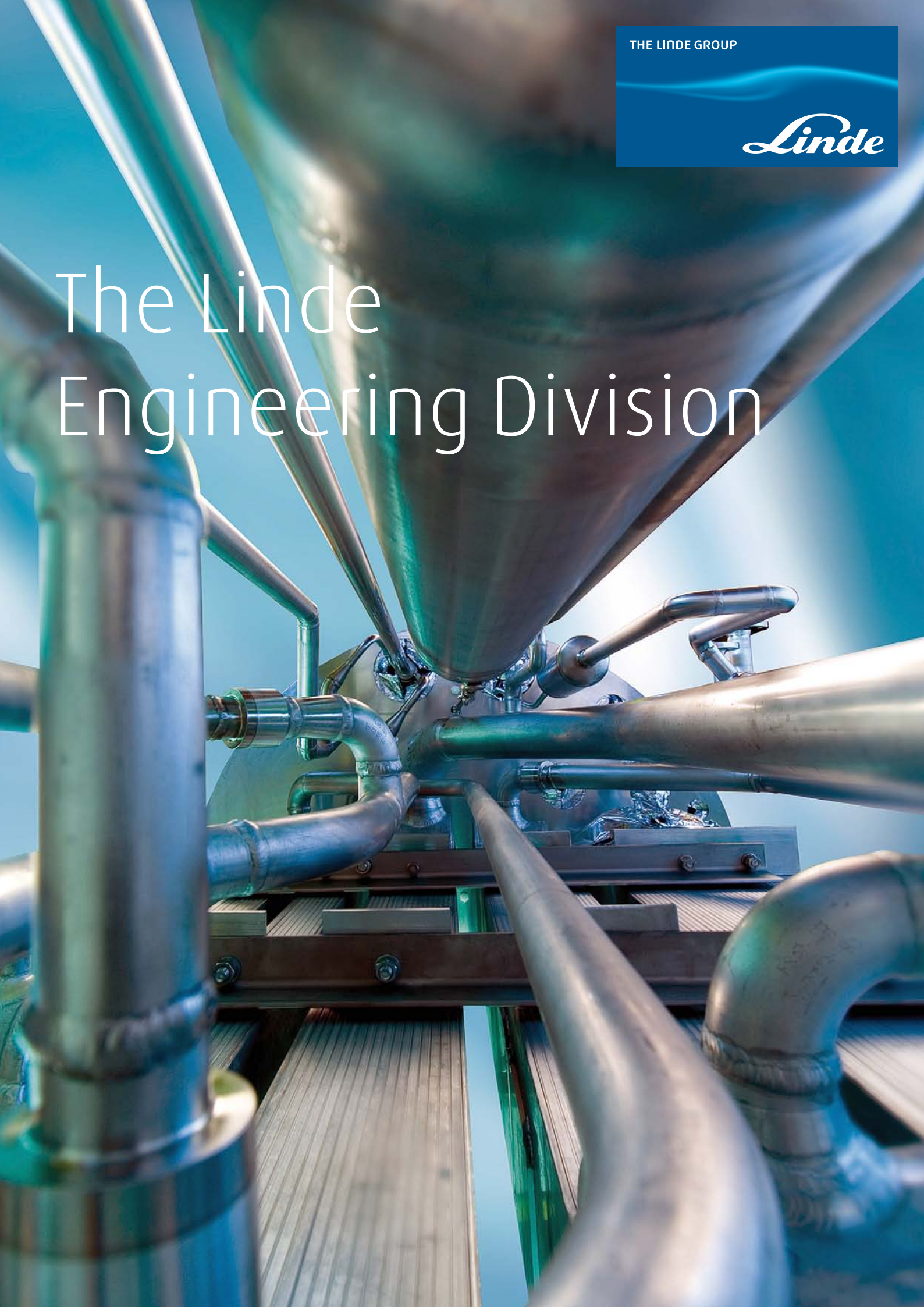


THE LINDE GROUP

Linde

The Linde Engineering Division



Introduction.

Introduction to The Linde Group

The Linde Group has a world-wide reputation as a producer of industrial gases, an engineering contractor with its own process know-how and a manufacturer of industrial equipment.

The original firm „Gesellschaft für Linde's Eismaschinen“, started in 1879 by refrigeration pioneer Carl von Linde, has grown into a corporation occupying the front rank of suppliers in its present day field of activity – gas and engineering as well as logistic services.

The Linde Group operates in around 100 countries with almost 48,000 employees. It achieved sales of EUR 11.211 billion in the 2009 financial year. The Engineering Division in Pullach near Munich (Germany), with more than 30 subsidiaries and affiliates, has around 5,700 employees all over the globe.

The Engineering Division is successful throughout the world, with its focus on promising market segments such as olefin plants, natural gas plants and air separation plants, as well as hydrogen and synthesis gas plants.

In contrast to virtually all our competitors, we are able to call on our own extensive process engineering know-how in the planning, project development and construction of turnkey industrial plants.

Activities of the Engineering Division

Linde designs and builds turn-key plants and supplies all services for process engineering projects.

Linde plants are used in a wide variety of fields: in the petrochemical and chemical industries, in refineries and fertilizer plants, to recover air gases, to produce hydrogen and synthesis gases, to treat and liquefy natural gas, and in the pharmaceutical industry.

The wide spectrum of Linde technologies is characterized by the scope of temperatures applied, ranging from -271 °C in a cryogenic plant for liquid helium up to +1,200 °C in the cracking process of an olefin plant.

Linde plants.

Chemical and petrochemical plants

Linde offers technologies for a wide range of petrochemical plants, such as turnkey plant complexes for the production and recovery of

- ethylene,
- propylene,
- acetylene,
- butadiene,
- gasoline and
- aromatic compounds

from

- ethane,
- propane,
- LPG,
- naphtha,
- gas oil,
- hydrocracker residues,
- natural gas condensates and
- refinery gases.

In addition to these plants for primary conversion of petrochemical raw materials, Linde can offer plants for downstream products like polyethylene and polypropylene. Linde's portfolio also includes process and refinery furnaces for petrochemical companies, refineries, gas processing concerns, steel producers, the pharmaceutical industry and environmental engineering groups.

Hydrogen and synthesis gas plants

Linde has the know-how and the experience to plan, design, supply and construct complete plants for the production of hydrogen, carbon monoxide and mixtures of these two gases (synthesis gas) as well as ammonia and methanol from the feedstocks: natural gas, liquefied gas, naphtha, residual oil and coal.

Gas processing plants

Gas processing plants are a group of single process units offered by Linde which include a great deal of proprietary process and component manufacturing know-how. They serve for the purification and separation of gas mixtures and are based on physical and chemical scrubbing processes.

The following processes are used in Linde's modern plant design:

- Partial condensation processes
- Liquid methane washes
- Carbon dioxide liquefaction
- Liquid nitrogen washes
- Separation of hydrogen and LPG from refinery fuel gas
- Purge gas separation
- Pressure swing adsorption
- Physical and chemical washes

Ethylene plant in Antwerp, Belgium





LNG plant in Hammerfest, Norway

Natural gas plants

Cryogenic processes represent the most economic solutions for separating natural gas components.

Nitrogen removal is used for conditioning natural gas and leads to reduced transportation volumes and an increased heating value.

When present, the recovery of helium can be combined with nitrogen removal. High purity helium is produced by the combination of cryogenic and pressure swing adsorption process steps.

NGL, LPG and condensate as well as the pure components methane, ethane, propane and butane often have higher sales values compared to the pipeline gas itself. Therefore, they are often extracted and fractionated in tailor made process plants according to the specific requirements of the regional market and the customers.

The Engineering Division offers all the required processes for pretreatment and separation of natural gas as well as the extraction of NGL, LPG, nitrogen and helium. Combined with Linde’s project execution know-how, these processes can be implemented on a turn-key basis for all manner of natural gas projects.

Natural gas liquefaction plants

Calling on more than 125 years of experience as a cryogenic plant designer, Linde is able to offer natural gas liquefaction plants based on its proprietary technology on a turn-key basis for a wide range of uses and capacities:

- World-scale baseload LNG plants
- Small to mid-scale base load and peak-shaving plants
- LNG Floating Production Storage and Offloading vessel (FPSO)

Natural gas typically contains a mixture of methane and heavier hydrocarbon gases, as well as carbon dioxide, nitrogen, water and a range of undesired components. Undesired components must be removed and the heavier hydrocarbons must be separated prior to liquefying and transporting natural gas. This involves a combination of adsorptive, absorptive and cryogenic processes - all of which are part of Linde’s core competence.

In addition to its engineering capabilities, the Engineering Division is also a manufacturer of key cryogenic equipment. This puts Linde in the unique position to select the most suitable type of heat exchanger - brazed aluminium plate-fin or coil-wound - dependant on the project requirement.

Alpha olefin plants

Alpha olefins are unsaturated linear hydrocarbons with a double bond between the first and the second carbon atom.

Alpha olefins are primarily used as copolymers in polyethylene and polypropylene production. Adding alpha olefins to the above mentioned polymers increases flexibility and strength in the end product. 1-hexene is most commonly used, but 1-octene and 1-pentene are also used by the polymer producers.

Alpha olefins have traditionally been produced by oligomerisation of ethylene. Extract of these components from coal-to-liquid product streams is an alternative production method.

Linde has a proven track record for the execution alpha olefin projects, based on technologies jointly developed with key clients.

Air separation plants

Air separation plants generally produce oxygen, nitrogen, argon and – in some special cases – other rare gases (krypton, xenon, helium, neon) by cryogenic rectification of air. The products can be produced in gaseous form for pipeline supply or as cryogenic liquids for storage and distribution by truck.

Linde has built approx. 2,800 cryogenic air separation plants in more than 80 countries and has the leading market position for air separation plants. This position results from the outstanding technology, high quality and reliability of our plants, containing a high proportion of in-house manufactured components, together with effective contract execution.

Packaged air separation plants

are modularly designed cryogenic plants with a daily production capacity of up to 450 tons (13,000 Nm³/h) oxygen or up to 900 tons (30,000 Nm³/h) nitrogen. If required these plants can also produce argon. Within the last 20 years Linde has built approx. 500 packaged air separation plants.

Tonnage air separation plants

are plants that are individually designed for the specific demands of our customers. These plants can produce oxygen, nitrogen, argon, krypton, xenon, helium, and neon.

Oxygen production capacities are between 450 tons (13,000 Nm³/h) and 7,000 tons (200,000 Nm³/h). Within the last 20 years Linde has built approx. 100 tonnage air separation plants.

Hydrogen and synthesis gas plants

Linde as a leading supplier of syngas technology designs, supplies and constructs entire synthesis gas plants for the production of carbon monoxide, hydrogen and mixtures of these gases as well as ammonia and methanol plants.

Providing the whole range of processes Linde can select the most appropriate solution for each case from the options: steam reforming, tandem reforming (gas heated reforming), autothermal reforming, partial oxidation and CO₂ reforming.

Linde has the design know-how and inhouse experience on processing all hydrocarbon feedstocks from natural gas, LPG, naphtha up to residual oil and heavier feeds.

Having available the whole range of processes and being experienced in the design of all feedstocks and capacities, Linde can select the technically and economically most favourable configuration.

Air separation plant in Montereau, France





Syngas plant with downstream pressure swing adsorption in Oberhausen, Germany

Pressure swing adsorption plants

Linde is a leading supplier of Pressure Swing Adsorption (PSA) plants for the recovery of pure hydrogen from various hydrogen-rich streams as well as for the recovery of CO₂ and CH₄ from process gases. Also plants for oxygen and nitrogen generation based on adsorption technology are offered by Linde in a wide range of capacities.

Cryogenic plants

Cryogenic plants are used for the liquefaction and storage of helium and hydrogen.

Biotechnological plants

These plants are for the industrial and the pharmaceutical biotechnology, for chemical synthesis of pharmaceutical substances and for the formulation of pharmaceuticals.

Manufacturing

Linde designs and manufactures core equipment for the processes and plant types covering its own product portfolio. Moreover this equipment is also sold to third party customers, some of them being our competitors within the market for process plants.

The scope of supply comprises:

- Cold boxes
- Tanks for liquefied gases
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Storage tanks for cryogenic gases
- Air-heated vaporizers
- Water bath vaporizers
- Spiral-welded aluminium pipes

Coil-wound heat exchanger in Linde's own fabrication facility



Designing processes – constructing plants.

Linde's Engineering Division continuously develops extensive process engineering know-how in the planning, project management and construction of turnkey industrial plants.

The range of products comprises:

- Petrochemical plants
- LNG and natural gas processing plants
- Synthesis gas plants
- Hydrogen plants
- Gas processing plants
- Adsorption plants
- Air separation plants
- Cryogenic plants
- Biotechnological plants
- Furnaces for petrochemical plants and refineries

Linde and its subsidiaries manufacture:

- Packaged units, cold boxes
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic standard tanks
- Air heated vaporizers
- Spiral-welded aluminium pipes

More than 3,800 plants worldwide document the leading position of the Engineering Division in international plant construction.

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