In-house expertise you can count on

Manufacture and delivery of key air separation components worldwide
Coldbox lifting in Sagunto, Spain.

“Understanding our customers’ needs, offering a value-creating solution and executing are key capabilities at Linde Engineering.”

Jürgen Nowicki
Managing Director
Member of the Board of Directors

As one of the largest and most experienced suppliers of air separation plants and industrial gases worldwide, Linde has already delivered over 3,000 air separation plants around the globe. In addition, we operate more than 400 air separation units (ASUs) ourselves. Building on our long-standing experience in both plant engineering and operation, we have developed a portfolio of modular ASUs to meet today’s air separation challenges. For more complex, challenging projects, we design and deliver customised plants, which we assemble on site to meet individual needs. In fact, we have successfully engineered and executed most of the largest air separation complexes in the world today. This vast, hands-on experience makes us the partner of choice for today’s air separation projects. The quality of these plants – whether customised or modular – obviously hinges on the quality of their component parts.
Engineering excellence – made in house.

To ensure the success and reliability of all our plants, we design and manufacture all key cryogenic components at our own fabrication workshops in Schalchen, Germany, and Dalian, China. The fact that the plant and process engineering team and as the manufacturing team are integral parts of one company ensures seamless project execution and premium quality every step of the way. All of which contributes to the lowest possible total cost of ownership (TCO) for our customers.

Key components for air separation plants manufactured in house include:
- Plate-fin heat exchangers (PFHES)
- Rectification columns
- Packings, sieve trays, distributors, collectors
- Completely assembled and pressure-tested coldboxes

Benefits of in-house manufacturing

Our in-house manufacturing expertise brings a range of benefits to our customers around the world. These include:
- Lowest total cost of ownership (TCO) thanks to proven, high-quality parts leveraging proprietary engineering
- Timely deliveries with fixed manufacturing slots and flexibility to prioritise projects and adjust manpower on demand
- Highly skilled, in-house fabrication specialists
- Flexibility to combine in-house manufacturing with on-site fabrication to deliver world-scale ASUs
- In-house development of new technologies for cryogenic equipment and manufacturing techniques
- Ongoing optimisation thanks to full lifecycle management
- Short project timelines due to common tools and globally standardised processes
- Price stability
PFHEs are key components in many process plants. They can be implemented across a wide range of applications, especially in low-temperature services. Due to their compactness, they offer both footprint and cost gains. In air separation plants, PFHEs are used to cool down the process air to near-liquefaction temperature. They offer a number of operational benefits:

- Very high specific heating area per volume
- Small temperature differences feasible
- Multiple streams possible
- Low pressure drops
- Fast response to flow and temperature duty changes

**Designed to last**

Since 1981, our manufacturing workshops have built over 12,000 vacuum-brazed PFHEs at our sites in Germany and China. Around the world, these PFHEs enjoy a strong reputation for their market-leading quality and technical reliability across a wide variety of cryogenic applications. The fact that many of these PFHEs are still in operation after decades of service bears clear testimony to the enduring nature of our designs.

**The brazing advantage**

Our PFHEs are manufactured at our global production facilities using vacuum brazing technology that does not require flux. This means that all cores are delivered completely free from corrosive residue. Brazing is one of our core areas of expertise. We advise our customers on the brazing furnace best suited to each application scenario and we operate several vacuum furnaces in Germany and China. This gives us the flexibility to meet demand for rapid turnarounds. Regardless of the complexity and size of the assembly, we can deliver sophisticated solutions designed to the highest quality standards – on time, on spec and on budget.
A PFHE consists of alternating layers of fins separated by parting sheets that have been brazed together with side bars. Process streams flow along the passages created by the fins between the parting sheets to exchange heat.

PFHEs can treat many process streams in one single unit thanks to the flexibility of layer stacking and the overall heat exchanger dimensions. They can be used to vaporise and condense both single- and mixed-component liquid and gaseous streams, supporting counter-flow and cross-flow arrangements. The aluminium alloys we use to fabricate brazed PFHEs provide the best possible heat transfer performance, thus enabling low-temperature differences down to 1 K.

This drastically reduces equipment weight, the size of the heat exchanger and the size of support structures.

By selecting the fin type best suited to each customer’s needs, we can optimise the thermal and hydraulic performance of the exchanger. We cover the full spectrum from plain through perforated to serrated fins, and from stand-alone PFHEs through manifold assemblies to block-in-shells and coldboxes. Our compact designs ensure the best surface to volume ratio – values of more than 2,000 m²/m³ are possible. Up to 20 streams can be accommodated within one heat exchanger.

Over 12,000 plate-fin heat exchangers delivered since 1981.

A closer look

Over 12,000 plate-fin heat exchanger fabrication.
Key components in focus: rectification columns.

Since Carl von Linde pioneered industrial air separation in 1902, rectification columns have been at the heart of cryogenic separation units. They determine the recovery rate and the purity of the gases produced. Innovative column designs thus make a big contribution to the energy efficiency of a plant and the required capital investment.

Linde workshops both in Germany and China offer structured packings and sieve trays to optimise the process design regardless of the application. Linde’s process design and manufacturing know-how in sieve trays and packings covers everything from primary and secondary structures through collectors to distributors for gas and liquid. Furthermore, Linde owns the intellectual property of many of the key features of this equipment.

A closer look

Since the mid-1980s, packed columns have been used in the cryogenic rectification process of air separation plants. They offer a number of advantages over sieve trays:

- The specific pressure drop of one mass transfer unit made of structured packing is much lower than that of packed columns. This paved the way for the recovery of pure argon by means of rectification.
- The possible load range for the gas and liquid is higher, which makes the plant more flexible.
- The liquid inventory of a packed column is lower than that of a tray column. This allows the plant to respond to load changes more quickly.

Our portfolio of structured packings has evolved since the first designs in the 1980s. Moving beyond aluminium packings without secondary structure and with a foil thickness of 0.2 mm, we now apply aluminium or copper with 0.1 mm thickness and a very efficient secondary structure. This creates a larger free area for the gas flow while reducing diameters for the same or similar loads. Higher efficiencies enabled by the secondary structure reduce the column height. Both factors combine to reduce capital investment cost.

Although many plants use structured packings in their columns, we have good reasons for keeping sieve tray technology in our portfolio:

- Elevated pressure rectification is more efficient with sieve tray columns
- Short sections with a limited number of trays can be realised more easily with sieve trays

The spectrum of column designs covers all air separation technology needs for the most efficient solution – spanning diameters from 800 mm to 6,350 mm, and column sections from two theoretical trays up to 20 theoretical trays.

Our portfolio of structured packings made from aluminium alloy and copper with film thicknesses of 0.1 mm and 0.2 mm extends from specific surfaces of 350 m²/m³ all the way up to 1,200 m²/m³.
Sieve tray fabrication work at the Schalchen plant.
Assembling cryogenic plant components in advance is often an economical alternative to installation on site, as it accelerates the erection and start-up process. PFHEs and columns can be assembled into a steel container known as a coldbox. Usually, PFHEs and columns are assembled in two separate boxes: the PFHE box and the rectification box. If the plant is also designed for argon recovery, the corresponding columns with piping are housed in a separate third box. These pre-packaged, pre-tested coldboxes are delivered ready to operate for fast erection and start-up. Very little welding and testing work is required as they already contain all the piping, valves and inline instruments needed.

We deliver road-transportable coldboxes with innovative structured packing supporting gaseous oxygen capacities up to 30,000 Nm³/h. Coldboxes for larger gaseous oxygen capacities of up to 160,000 Nm³/h are transported by sea. As our workshop in Dalian has direct sea access, it is perfectly suited to the delivery of large packaged unit coldboxes.

Packaging options

We offer a variety of delivery modes to suit individual customer needs:

→ At our workshop, the equipment is ready-piped and assembled in the coldbox and the complete coldbox is shipped to the customer site as a packaged unit, pre-tested and ready to operate.
→ The equipment is pre-assembled with nozzles, sealed and filled with nitrogen – ready to be installed in the coldbox on site.
→ The equipment is delivered in sections to the site and then the parts are installed in the coldbox, which is then welded and pressure-tested on site.
→ Very large equipment is always assembled on site.
Advantages of block-in-shell units

Largest pre-fabricated ASU coldbox.
More than 8,000 tonnes of aluminium processed per year.

In-house expertise you can count on Linde Engineering Schalchen, Germany.

Our production facilities in Pullach near Munich, Germany, stretch over 52,000 m². The shop floor accounts for 13,000 m² of this and 2,600 m² is office space. This location is dedicated to the brazing of PFHEs. We operate six brazing furnaces at this site.

Our Schalchen yard, located approx. 100 km east of Munich, is larger with a total footprint of 200,000 m². It includes 22 production shops and 66,000 m² of shop floor, 7,000 m² of office space and 23 production shops for the fabrication of cryogenic equipment. It is our main fabrication point for plant components: over 100 coldboxes and more than 100 columns per year are manufactured at Schalchen’s production facilities.

Further production capacity is available at our module yards in Bremen, Germany, and Tarragona, Spain.

These production sites specialise in the engineering, production and sale of:

- Plate-fin heat exchangers
- Cryogenic columns
- Packaged unit coldboxes
- Spiral-welded aluminium pipes
- Cryogenic tanks
- Water bath vaporisers
- Air-heated vaporisers
- Coil-wound heat exchangers

Read more: linde-engineering.com/air_separation_plants

Aerial view of module yard in Bremen, Germany.
Established in 2005, Linde Engineering (Dalian) Co. Ltd. has a 37,000 m² workshop and 4,000 m² of office space. Direct sea access to the port makes this location highly advantageous for the transportation of large coldboxes. Over 30 coldboxes and more than 60 columns are manufactured at our Dalian site every year.

This production site specialises in the engineering, production and sale of:
- Plate-fin heat exchangers
- Columns
- Packaged unit coldboxes
- Pressure vessels
- Molsieve adsorbers
- Coil-wound heat exchangers
- Air-heated vaporisers
- Water bath vaporisers
Office building in Dalian, China.
Linde Engineering.

Facts and figures.

Our air separation business.

Composition of air

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<thead>
<tr>
<th></th>
<th>Vol %</th>
<th>Boiling point</th>
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<tbody>
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<tr>
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Number of patents

150 new air separation patents in last 5 years

3,000+ air separation plants have been built by Linde

400 air separation units owned and operated by The Linde Group

World’s largest single train air separation unit built by Linde

5,250 tpd oxygen

1902 World’s first air separation unit for oxygen production

1990 Linde introduced argon production by rectification.
In-house expertise you can count on

Biggest prefabricated coldbox:

**Height 70 m**

**Weight 800 t**

19% TCO (Total Cost of Ownership) savings in past 10 years

-15% average power consumption of our ASUs over the last 10 years

Heat exchanger

1,700 m²/m³ max. surface

Linde air separation units built in more than 90 countries

Read more: linde-engineering.com/air_separation_plants

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Your partner for the production and processing of gases

Delivering reliable process plants for maximum capital efficiency
Linde has been optimizing gas processing technologies for 140 years, successfully delivering more than 4,000 plant engineering projects around the globe. Favoring trusted, lasting business relationships, the company collaborates closely with customers to enhance plant lifecycle productivity and innovate process flows. The company’s proven gas processing expertise plays an indispensable role in the success of customers across multiple industries – from natural gas and oil refining through petrochemicals and fertilizers to electronics and metal processing.

Operational excellence along the entire plant lifecycle
We work closely with our customers to gain an in-depth understanding of individual needs. Building on the unique synergies of Linde as an integrated plant operator and engineering company, Linde offers innovative process technologies and services to exceed our customers’ reliability and profitability expectations. This commitment to innovation extends along the entire plant lifecycle. The LINDE PLANTSERV® service team supports customers every step of the way – from maintenance and repairs to full revamps. Leveraging the latest digital technologies to offer on-site and remote operational and support services, we consistently take asset performance to the next level.

Making the impossible possible
From the desert to the Arctic, from small- to world-scale, from standardized to customized designs, Linde’s engineering specialists develop solutions that operate under all conditions. The company covers every step in the design, project management and construction of gas processing plants and components. Customers can always rely on Linde to deliver the plants, components and services that fit their needs best – anywhere in the world.

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

Get in touch with our air separation plant team:
Phone +49 89 7445-3526, inquiry: www.linde-engineering.com/contact

Core competencies at a glance

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<thead>
<tr>
<th>Plant engineering</th>
<th>Component manufacturing</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ Air separation plants</td>
<td>→ Coldboxes and modules</td>
<td>→ Revamps and plant modifications</td>
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<tr>
<td>→ LNG and natural gas processing plants</td>
<td>→ Coil-wound heat exchangers</td>
<td>→ Plant relocations</td>
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<tr>
<td>→ Petrochemical plants</td>
<td>→ Plate-fin heat exchangers</td>
<td>→ Spare parts</td>
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<tr>
<td>→ Hydrogen and synthesis gas plants</td>
<td>→ Cryogenic columns</td>
<td>→ Operational support, troubleshooting</td>
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<tr>
<td>→ Adsorption plants</td>
<td>→ Cryogenic storage tanks</td>
<td>and immediate repairs</td>
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<tr>
<td>→ Cryogenic plants</td>
<td>→ Liquefied helium tanks and containers</td>
<td>→ Long-term service contracts</td>
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<td>→ Carbon capture and utilization plants</td>
<td>→ Air-heated vaporizers</td>
<td>→ Expert reviews for plants, operations</td>
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<tr>
<td>→ Furnaces, fired heaters, incinerators</td>
<td>→ Water bath vaporizers</td>
<td>and spare part inventory</td>
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<td></td>
<td>→ Spiral-welded aluminum pipes</td>
<td>→ Operator training</td>
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