Aluminium plate-fin heat exchangers.
Proven technology in a variety of designs.
Proven expertise.

"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

Designed to last
Since 1981, we have built over 12,000 vacuum-brazed plate-fin heat exchangers (PFHE) at our sites in Germany and China. Around the world, these Linde PFHEs enjoy a strong reputation for their 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.

As one of the founding members of the Aluminium Plate-Fin Heat Exchanger Manufacturer’s Association (ALPEMA), we have made a valuable contribution to the advancement of PFHE technology over the years.

Winning combination
Our PFHEs are designed to the individual needs of each customer. You can rely on our engineering experts to factor in your thermal and hydraulic performance requirements along with your availability and lifetime expectations while keeping investment costs and operation costs to a minimum.

By combining optimized design with proven technologies and the highest quality standards, we offer our customer state-of-the-art solutions. Our experts can also increase the lifetime of your equipment by analyzing your process and reducing thermal and mechanical stress to the equipment.
Linde – partner of choice.

One of the world’s largest brazing capacities

Our PFHEs are manufactured at our global production facilities using vacuum brazing technology. One of the largest brazing capacities in the world gives us the flexibility to meet customer 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.

Broad experience base

We deliver PFHEs to a broad customer base, including Linde entities around the world, third parties and design institutes. The fact that we gain hands-on experience using our own equipment gives us a decisive edge, enabling us to channel these operational insights into design fine-tuning and the continued exploration of optimization potential.

Knowledge sharing

Our customer-centric teams bring together professional engineers, skilled employees and trained maintenance and service staff. These highly skilled and specialized teams travel the globe to support our customers during the entire equipment life cycle - from installation through start-up to maintenance and

Our customers know that our service team is just a call away and that they can always rely on the vast and bundled experience we have gained over the years to solve even the most stubborn of challenges. These include processes that demand design pressures up to 130 bar, temperatures as low as 3 K and temperature differences of less than 1 K.
What is a plate-fin heat exchanger?

PFHEs are key components in many process plants. They offer space and cost advantages over other types of heat exchangers such as shell and tube heat exchangers. An exchanger consists of alternating layers of fins separated by parting sheets. With the exception of the fluid inlets and outlets, the edges of each layer are sealed with side bars which give the unit mechanical strength and prevent fluids from leaking to the atmosphere. The layers are brazed together in the sequence defined at the design stage.

Process streams flow along the passages created by the fins between the parting sheets to exchange heat. The primary heat transfer surface within the PFHE consists of the parting sheet and the fin section which is directly brazed to the parting sheet. The secondary heat transfer surface is provided by the fins. PFHEs can treat many process streams in one single unit thanks to the flexibility of layer stacking. They can be used to vaporize and condense both single- and mixed-component liquid and gaseous streams, supporting counter-flow and cross-flow arrangements. Each process stream occupies a certain number of passages within the stack. These are merged with half-pipe headers and nozzles to create single-point connections on both the inlet and outlet side. This multi-stream capability combined with single-point connections optimizes process efficiency and avoids expensive interconnecting piping between different units.

The aluminium alloys used in the fabrication of brazed PFHEs provide the best possible heat transfer performance, thus enabling low-temperature differences down to 1 K. This drastically reduces equipment weight and the size of the exchanger.

Both the overall design and choice of fins is always engineered to meet each customer’s specific needs. We also run feasibility studies in collaboration with our customers to simulate both technical

---

**Structure of PFHE**

1. **Warm (condensing) fluid**
2. **Cold (boiling) fluid**
3. **Warm fluid**
4. **Cold fluid**
5. **Nozzle**
6. **Header**
7. **Distributor fin**
8. **Heat transfer fin**
9. **Parting sheet**
10. **Side bar**
11. **Cover plate**
Plate-fin heat exchangers form the core components of many plants.

What are PFHEs used for?

PFHEs are used for a wide range of applications, especially for low-temperature services and treatment of clean fluids. In many cases, the PFHE is essential to the overall process flow. The main applications include:

- Air separation plants
- Natural gas liquefaction plants
- Petrochemical plants
- Gas treatment plants
- Helium liquefaction plants

The brazing advantage

Our PFHEs are brazed in vacuum furnaces without using flux. This means that all cores are delivered completely free from corrosive residue, and post-brazing cleaning steps are not required. This brazing process is highly complex and tightly controlled to ensure that each fin and plate bond correctly. Millions of joints are brazed in each PFHE.

Brazing is one of our core areas of expertise. We operate several vacuum furnaces in Germany and China, which mean we can serve customers around the world with speed and flexibility. After vacuum brazing, the PFHEs are completed by welding all the attachments to the core. These include half-pipe headers, nozzles, support brackets and lifting trunnions.
PFHEs are manufactured from raw materials in a multi-step process with all steps rigorously controlled to ensure the highest quality. After the headers and nozzles have been welded to the core, the completed heat exchangers are subjected to non-destructive testing. This includes hydraulic or pneumatic pressure testing and leak testing.
Designed for individual needs

**Perfect fit.**

Different fin types mean we can optimize the thermal and hydraulic performance to customer needs. 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 cold boxes. This ensures that we can provide the perfect fit for each customer’s application challenges, performance needs and budgetary constraints. Customers can also rely on our experts for process consulting support to optimize overall system design and help reduce operating costs further down the line.

**Design versatility**

We use a variety of materials, fins and assembly models to match individual performance needs and cost constraints. Our compact designs ensure the best surface to volume ratio – more than 2000 m²/m³ are possible. This allows us to reduce weight, aluminium requirements and support structures. In addition, to minimize the number of exchangers required we build heat exchangers that are up to 8.2 metres in length, 1.5 meters in width and 3.4 meters in height.

**The right materials**

We use a variety of aluminium alloys to ensure optimum performance. These include type 3003 for cores and 5083 for headers and nozzles. Customers can also request ASTM 5454/EN AW 5454. These materials are also suitable for higher temperatures (up to +93°C). Depending on the design code applicable to pressure vessels (i.e. the ASME code or EN code), we choose the materials and combinations best suited to individual performance needs.

**Variety of fin corrugations**

We use a variety of fins with different corrugations and variable heights and densities to match hydraulic and thermal performance characteristics with individual needs. The geometry of these fins has been gradually optimized drawing on the experience gained in the field over the last 35 years. Different fin types can also be combined in a single stream.

**Features for improved mercury resistance**

Based on our long-standing, hands-on experience, we incorporate a range of mercury-tolerant features into our PFHE designs to provide the highest possible levels of mercury resistance. We generally recommend operating PFHEs within the range stated in ALPEMA. Above this range – depending on the actual design conditions – we often advise building in guard beds in order to minimise the risk of material corrosion as a result of mercury.
Packaging options.

Our exchangers are also available in a variety of delivery modes to suit individual needs. Customers can choose between single exchangers and fully integrated assemblies and cold boxes.

**Single units**

Our PFHEs can be supplied as single units with stub pipes, material transitions plus aluminium or stainless steel flanges for connection to the plant piping.

**Manifold assemblies**

If the required heat transfer performance cannot be achieved with a single PFHE, we offer manifold assemblies. These PFHE assemblies are batteries of two or more PFHEs. This complete heat exchanger system can be transported in a steel frame or in a combined transportation/operation frame for later use.

**Cold boxes**

One or more PFHEs are installed in a steel casing (normally carbon steel) which may include interconnect piping, phase separator vessels, rectification columns, appropriate valves and instruments as well as insulation material (perlite). The cold boxes are provided with flanges at the wall outlets for easy connection to on-site piping. Depending on the application, the cold box footprint can be rectangular or circular. Cold box advantages include:

→ These units are ready to operate, only perlite to be filled in.
→ No additional support structures are required.
→ The equipment integrated in the box is protected.
→ Insulation material can be replaced quickly and easily.
Block-in-shell units

Our block-in-shell units consist of one or more PFHEs installed in a steel shell. While matching the service of shell and tubular heat exchangers, these units offer a number of advantages:

→ Reduced temperature approach (less than 1 K), which results in energy savings.
→ Up to ten times greater heat transfer area per unit.
→ Smaller size, weight and footprint.
→ Lower installation costs.

Over 12,000 premium-quality plate-fin heat exchangers delivered since production started in 1981.
Technical data.

Quality management and inspection

Quality management is an essential part of our company strategy.

Linde is certified according to:

- EN ISO 9001/EN ISO 14001
- German Pressure Vessel Rules (AD-HPO)
- ASME (U, U2)
- National Board (NB, R)
- Manufacture license of special equipment (China)
- Certificate of manufacture registration of cylinder (Korea)

Acceptance inspection is carried out by our own specialists and also by experts from various international inspection organisations, such as:

- TÜV (German Safety Inspectorate)
- Arise
- Others on request

Design standards

The process and mechanical design blueprint for PFHEs builds on our know-how as a leading engineering company for turnkey plants. We are a founding member of the Aluminium Plate-Fin Heat Exchanger Manufacturer’s Association (ALPEMA) and also member of other international organizations such as HTRI and HTFS.

Equipment design and manufacturing, based on our customer’s specifications and our own standards, are carried out in accordance with national and international standards such as:

- PED European Pressure Equipment Directive
- European standards
- ASME Code
- Chinese standards
- Russian standards
- And others

Maximum dimensions per single heat exchanger:
Width: 1.5 m
Height: 3.4 m
Length: 8.2 m

Design temperature:
~269°C to + 93°C (200°F)

Design pressure:
Up to approx. 130 bar (1886 psig)

Materials:
Core:
ASTM 3003/EN AW 3003

Headers, nozzles, flanges:
ASTM 5083/EN AW 5083
ASTM 5454/EN AW 5454

Ready for transportation.
Quality management and inspection.
Full service spectrum.

We offer a broad range of engineering, installation and after sales services to support our customers from the initial design and simulation stage throughout the whole lifetime of the equipment.

Optimization of PFHE lifetime expectancy

PFHE customers are generally keen to maximize temperature and pressure capabilities. Instead of applying low, standard operating limitations for dynamic temperature differences, we have developed special 3D simulation tools to explore all fine-tuning and optimisation potential during the design process.

Through steady-state and dynamic simulations, we calculate the thermo-hydraulic performance, also applying computational fluid dynamics and finite element analysis for the best possible outcomes.

However, changes in the plant’s operation or in the load of the heat exchanger often mean a deviation from the original design. In these cases, a dependable assessment of the heat exchanger’s reliability and safety must be made.

With LIBAS® (Linde Brazed Plate-fin Analysis of Stress), Linde has developed a system which is able to reliably calculate the lifetime of the Linde heat exchanger on the basis of its geometry and real load data. The system is based on the combination of thermofluid-dynamic simulation with a finite-element analysis and has been extensively validated by practical tests.

Computational fluid dynamics (CFD) in action

We use CFD to simulate the flow distribution (from the nozzle into the half-pipe headers) and then calculate the velocities and pressure differences (as illustrated below). These insights allow us to optimize the layer arrangement in the core and thus extend the lifetime.
Finite element analysis (FEA) in action

As illustrated in the top left illustration, finite element analysis can be used to simulate all PFHE parts. We then use the geometry and process data to calculate the temperature profile (top right illustration). This, in turn, reveals the mechanical stresses that each part of the PFHE is exposed to (bottom left illustration).
**PFHE lifetime services**

In addition, we offer lifetime screening and assessment analysis, fault reconstruction and operational screening services.

**PFHE lifetime screening**

- **Step 1:** Interdisciplinary workshop (description of scenarios)
- **Step 2:** Rough criticality assessment
- **Step 3:** Top-rating critical cases

The PFHE lifetime screening service is available for both Linde and third-party PFHEs. Building on our experience and proprietary software, we provide a qualitative rating of all scenarios, highlighting critical cases in particular.

**PFHE lifetime estimation**

- **Step 1:** Pre-selected cases
- **Step 2:** Thermal/hydraulic simulation
- **Step 3:** Stress calculation/fatigue analysis
- **Step 4:** Event counting/Estimation of lifetime

The PFHE lifetime estimation service is available only for Linde PFHEs. Building on our experience and proprietary software, we provide a quantitative rating of all scenarios, highlighting critical cases in particular and allowing us to predict lifetime expectancy of a PFHE.

**Operational services.**

Our after-sales and field services can help you with everything from operational improvements and maintenance to periodic inspections at our manufacturing yard.

**Field installation**

Qualified and experienced erection engineers, fitters and welders are available to carry out and/or to supervise the installation of our PFHEs on site.

**Operation**

Our thermodynamic, hydraulic, process and mechanical engineering specialists are always ready to support you with thermal and hydraulic problem analysis and operational improvements.

**Cleaning**

If fouling or plugging in exchanger passages occurs, we can run an immediate analysis and present cleaning proposals. We can also supervise the cleaning process.
Repair service
Should a malfunction of your PFHE system occur, we have an emergency team that has the right qualifications, experience, certificates and tools to quickly help you with the required repair work. Moreover, we organise technology-based maintenance work for you, particularly the replacement or repair of a PFHE.

Your benefits
- Qualified analysis and consulting based on our technical expertise.
- Optimal execution of repairs by qualified manufacturing experts.
- Optimal value for money and quick delivery of essential consumables.
- Full aluminium welding expertise with all relevant certificates.

Repairs and troubleshooting
- Failure analysis and emergency service.
- Welding work on aluminium components such as heat exchangers and cold boxes.
- We provide the tools and equipment needed for the service on site.

Inspection and diagnosis
- Review of the condition of your PFHE.

Manufacturing excellence
All plate-fin heat exchangers are manufactured at our Linde Engineering sites in China and Germany. Schalchen (Germany) has been manufacturing premium-quality plant components and modules for the past 60 years. With over 800 engineers and skilled workers, Schalchen also offers field installation and advice on operation. A specialised service crew is available for immediate and professional on-site assistance.

At our site in Dalian (China), we combine leading technologies from The Linde Group with our professional management skills to support our customers with top-quality products and value-added services.

To find out how your process plant can benefit from our world-class technologies, global reach and outstanding support services, visit leamericas.com or contact your local Linde Engineering sales office.
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.leamericas.com

Get in touch with our team:
Phone: +281 717-9090, e-mail: sales@leamericas.com
www.leamericas.com

Core competencies at a glance

---

**Plant engineering**

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

**Component manufacturing**

- Cold boxes 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