

Best in Glass.

Industrial gases & leading technologies
for your business success.

O₂

H₂

O₂

N₂

Kr

O₂

Ar

SO₂

SiH₄

HF

SiH₄

C₂



Challenges.

04

Dedicated to your success

05

Partner of choice

Melting.

06-09

Principles of oxyfuel
melting

The COROX® family

Gas bubbling

Atmosphere analysis
& process control

Forming.

10

Protective atmosphere
for your tin bath

CARBOFLAM® – mould
coating for press and blow
forming processes

Surface treatment.

11

HYDROPOX® for
the perfect finish

Added functionality
with coatings

Window insulation & lighting.

12-13

Insulating for success

Leading light

Supply & services.

14-15

Our supply solutions

At your service





Challenges.

The glass industry faces many challenges, including competitive pressures, the need to cut production costs and increasingly strict environmental legislation. Linde has developed several solutions to help glass manufacturers face these challenges.

Improving efficiency while meeting regulatory and competitive pressures

Glass production is extremely energy intensive, accounting for as much as 20% of overall costs. This is a sizeable block in such a cost-sensitive business.

The production of glass also results in significant emissions, mainly carbon dioxide (CO₂) and nitrogen oxides (NO_x), but also sulphur dioxide (SO₂) and carbon monoxide (CO). The world over, legislation is imposing tighter controls on these emissions. In the EU, for instance, NO_x emissions are set to drop significantly by 2016.

In addition to these pressures, glass manufacturers are challenged to stay ahead of the innovation curve. This 7,000 year-old industry continues to evolve as expectations rise for coating and insulating innovations, but also for security and fire-rated glass, self-cleaning surfaces and smart capabilities.

Dedicated to your success

Industrial gases are an extremely effective way of meeting today's glass production challenges. We offer a wide range of gas applications, process technologies and services to cover all glass melting, forming and processing needs.

For instance, we deliver gas-enabled solutions to increase your energy efficiency and productivity. You can also rely on our technologies to help you reduce emissions and ensure legislative compliance. And – last but not least – Linde engineers have in-depth experience in many of today's leading process technologies. We can advise on the gases and supply modes best suited to helping you achieve the high-tech surface finish or properties you require.

Partner of choice.

As a global leader in the industrial gases industry, The Linde Group is the partner of choice for glass manufacturers. We can add value to your production processes by combining decades of experience in glass with market-leading, dedicated process innovations.

Our people

Our broad expertise covers everything from glass chemistry through furnace design to operations. You can rely on our experts to advise on combustion science, computational fluid dynamics modelling, glass surface treatment and control systems for both combustion and inerting atmospheres.

Proven performance

Over 100 reference projects around the world confirm the success of our proven technologies and gas supply solutions for oxyfuel melting, oxyfuel boosting, glass forming and glass surface treatment.

Dedication to innovation

Our R&D centres in Munich, Shanghai and New York ensure a steady pipeline of new application technologies. Examples include our COROX® LowNO_x solution and our COROX® roof-mounted oxyfuel burners. These development centres bundle and showcase our global expertise in glass. We also test and customise all of our innovations at these centres before delivering them to your site.

Collaborative approach to business

We work closely with you at all stages of the project to ensure the success of your investment in gas technologies and supply systems. This even includes post-installation fine-tuning to ensure full compliance with your productivity, energy efficiency and quality goals.

End-to-end offering

We support your entire solution lifecycle, starting with an in-depth analysis of your individual requirements right up to ongoing operation support and maintenance. Addressing all of your gas supply needs, this holistic approach ensures your project is completed on time, on quality and in budget. Individual steps include:

- Detailed as-is analysis (e.g. furnace data, CFD modelling)
- High-level solution proposal (e.g. burner type and number, positioning, firing strategy, etc.)
- Lab-scale trials
- Design fine-tuning and commercial offer
- Solution engineering, pretesting of components and control system
- Installation and commissioning, performance testing
- Safety assessment and training
- Maintenance and operation support



Melting.

When it comes to glass melting, choosing the right burner or lancing technology plays a crucial role in achieving your quality, productivity and emission targets. We have developed a range of proven solutions to help you meet your individual melting challenges.

Principles of oxyfuel combustion

Increasing process efficiency with oxygen
Using oxygen instead of or in addition to air in glass melting processes offers a number of advantages:

- For instance, oxygen eliminates the nitrogen ballast of air, dramatically reducing NOx formation and increasing flame temperatures (see figures 1 and 2).
- It also raises the concentration of CO₂ and H₂O in the vicinity of the flame. And since these gases are mainly responsible for thermal radiation, oxyfuel significantly increases thermal efficiency (see figure 2).

There are a variety of ways to increase combustion efficiency through O₂ when melting glass. These include oxyfuel melting, oxyfuel boosting and oxygen lancing. You will find more details on these on the following pages.

Benefits of oxyfuel combustion in detail

- Fuel consumption down by up to 50% due to improved heat transfer and lower flue gas heat losses
- 15% saving on the OPEX front
- Up to 40% rise in productivity due to faster melting cycles
- Emissions of NO_x, SO₂ and CO₂ down by up to 75%, 30% and 5% respectively
- Smaller flue gas management system thanks to reduction in flue gas volume (see figure 2)
- Up to 25% reduction in footprint due to elimination of air preheaters
- Reduction in investment and maintenance costs through elimination of regenerators and recuperators
- Improved process stability with stable furnace pressure through the elimination of regenerator changeover cycles

Figure 1: Reduced nitrogen ballast with oxyfuel combustion

■ Fuel ■ Air ■ O₂ ■ N₂ ■ CO₂ + H₂O

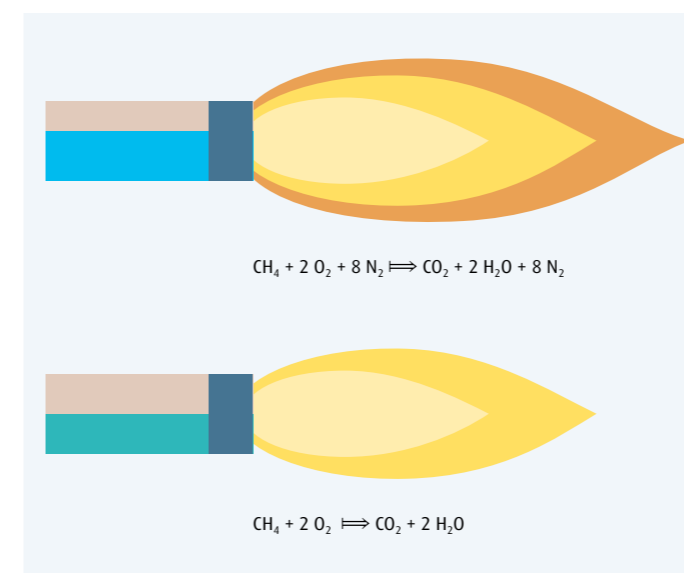
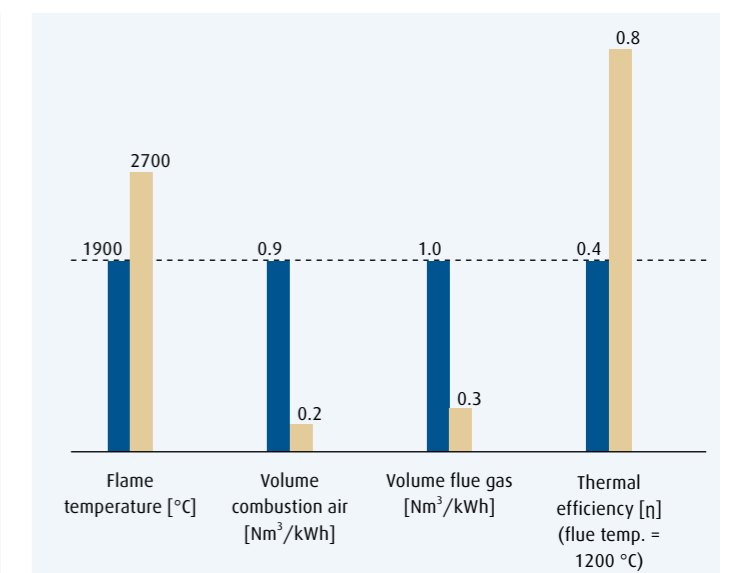


Figure 2: Improved efficiency with oxyfuel combustion

■ Air-fuel combustion ■ Oxyfuel combustion



The COROX® family

We have developed a broad portfolio of oxyfuel melting, oxyfuel boosting and oxygen lancing solutions to meet your individual productivity, emission control, cost and capacity needs. We also supply all gases required for gas bubbling and atmosphere analysis. Our engineers will work closely with you to establish the configuration and supply mode best suited to your individual targets.

COROX® oxyfuel melting

This solution is ideal if you:

- require very high melting temperatures (e.g. 1560 °C and higher)
- produce fibre or speciality glass
- need to improve energy efficiency
- need to reduce emissions
- need to increase your capacity
- operate heat recovery systems with low preheating temperatures (e.g. recuperative systems)
- wish to reduce your footprint

We supply gases and application technologies for side-port regenerative, end-port regenerative and recuperative furnaces. With a full range of burners (tube-in-tube as well as flat flame), we will recommend the model best suited to your specific furnace situation and operating challenges.



COROX® convective glass melting in operation

Highlights within our oxyfuel melting portfolio include our COROX® convective glass melting application, which is a unique roof burner solution that offers enhanced heat transfer capabilities (see figure 3). Thanks to the more targeted application of energy, it is more efficient than a traditional side-mounted burner:

- More melting capacity
- Less raw material needed
- Further energy savings
- Improved glass quality

COROX® oxyfuel boosting

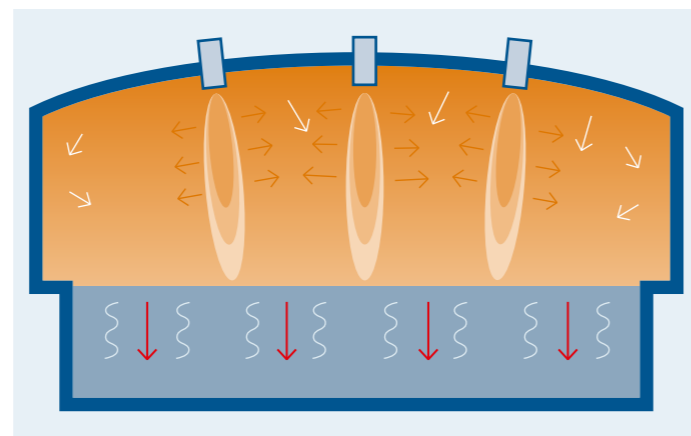
Boosting is the method of choice if you wish to:

- increase your melting capacity without changing your furnace footprint
- optimise the number of furnaces you have in operation

Complementing your air-fuel burners, oxyfuel burners are installed and/or oxygen is injected through high-pressure lances. This raises flame temperatures by eliminating nitrogen and increasing the oxygen concentration. As a result, oxyfuel boosting also raises the concentration of CO₂ and H₂O in the vicinity of the flame. And since these gases are mainly responsible for thermal radiation, they make the flames more efficient.

Figure 3: COROX® convective glass melting – roof burner solution

■ Radiant heat ■ Glass bath ■ Convective heat



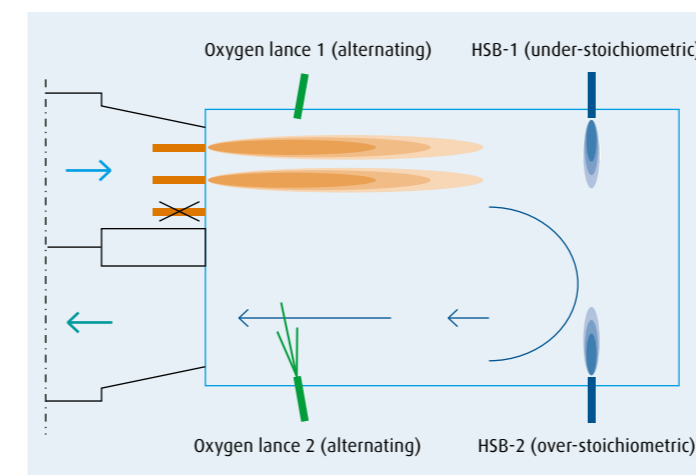
COROX® LowNOx

Our innovative COROX® LowNOx solution is the ideal way to reduce NOx emissions in order to comply with stricter legislation.

It involves injecting additional oxygen through high-pressure lances to create a more intense, directional flue gas recirculation effect within the furnace (see figure 4). As a result, the main air/gas burner system produces a diluted, staged combustion process. The fuel dilution leads to a more homogenous flame and a reduced flame temperature. As the flame temperature has a direct impact on NOx levels, this lowers emissions significantly. A lower flame temperature also reduces the concentration of hydrocarbon radicals in the furnace, thereby limiting NOx formation. In addition, an improved heat transfer rate shortens the window during which NOx can form.

Figure 4: Top view of COROX® LowNOx installation

■ Air ■ Flue gas



COROX® Oxyservice

This is a temporary installation designed to ensure continuity of service during maintenance or repair work.

Our COROX® Oxyservice is of particular interest to operators with a plugged regenerator or leaking recuperative heat recovery system. Here we deliver the oxygen lances and all supporting supply equipment for the duration of the maintenance work.

Gas bubbling

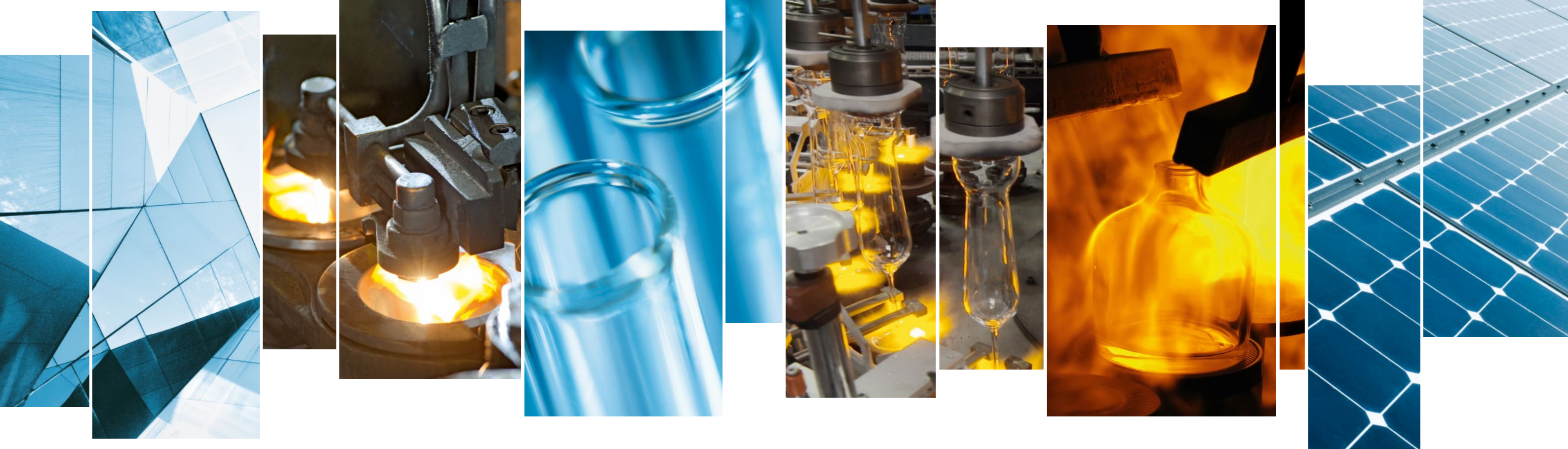
During melting and refining, gas bubbling through molten glass can help to enhance glass melting convection currents and improve re-adsorption of any remaining bubbles into the melt in order to eliminate defects.

Gases can also be bubbled through the melt to help improve glass conditioning. As oxygen is more soluble than air, it is an effective way to reduce seed formation. Helium is often used for premium products.

We provide the full range of regular and inert gases (e.g. He, O₂, N₂, Ar) and supply systems to support all bubbling applications.

Atmosphere analysis & process control

You can also rely on us to supply the full range of high-precision calibration gases and process control gas mixtures to support compliance with emissions regulations through accurate monitoring and reporting of atmosphere and flue gas measurements.



Forming.

Optimising your forming results with the gases you need in the right mixtures and purities, coupled with state-of-the-art flow control equipment.

Protective atmosphere for your tin bath

Gases play an important role in the forming of float glass, where a nitrogen/hydrogen atmosphere is used to avoid oxidation of the tin to minimise the tin count on the glass. The success of forming hinges on consistent delivery of your selected ratio and volume flow (e.g. 95% N₂ / 5% H₂) and on a secure supply of high-purity gases (N₂ 5.0 and H₂ 3.0).

The float glass forming process also relies on sulphur dioxide. This is injected near the transitional roll desk to improve the physical, chemical and mechanical properties of the glass surface and extend the life of the rollers.

We can help ensure the success of your float glass production line with reliable supplies of nitrogen and hydrogen in the required purity levels, complementing this with cost-effective, safe and reliable flow control equipment for optimum results. Depending on your volume requirements, we can supply these gases in bulk or install an ECOVAR® on-site supply system (for more information on ECOVAR®, see page 14).

CARBOFLAM® – mould coating for press and blow forming processes

One area of glass production that offers vast scope for efficiency gains is the surface coating of moulding tools with carbon. Compared with alternative methods for surface coating (manual lubrication, spraying and insulating with graphite suspensions, waxes, emulsions etc.), the application of carbon offers numerous advantages.

Our CARBOFLAM® solution is a versatile process that can be applied to all types of glass. It is the most effective surface coating technique because it makes use of the material-specific release and insulating properties of pure carbon. These include an even temperature level during mechanical glass forming.

Key benefits

- Higher productivity due to improved process stability and longer application time of the moulding tools
- Higher glass quality through elimination/minimisation of structural marks from the moulding tools on the glass surfaces
- New products due to improved glass distribution enabled by higher mould temperatures
- Lower maintenance costs through process optimisation
- Substantial reduction in workplace pollution compared with other applications (e.g. cracking applications)

Surface treatment.

Ensuring the perfect surface finish with sophisticated flame-based and coating technologies for high-end glass products.

HYDROPOX® for the perfect finish

Our HYDROPOX® flame-based solution offers a number of benefits in glass surface treatment for art & tableware (e.g. wine glasses), specialty glasses (e.g. display glasses) and high-value container glass (e.g. flacons).

Our solution comprises both pre-mixed and surface-mixed burners using oxygen, hydrogen or natural gas depending on your specific requirements.

With its homogenous flame curtain, HYDROPOX® ensures an even heat transfer and briefly brings the glass surface to a temperature above the softening point of the glass.

Key applications

- Increasing brilliance of the glass surface
- Eliminating seams and edges
- Healing of micro-cracks and failures

Key benefits

- Significant reduction in rejection rates
- Production of high-end glass products
- Enablement of new features – e.g. wine glasses without seams
- Very high production speeds – quality of hand-crafted glass at normal line speeds.

Added functionality with coatings

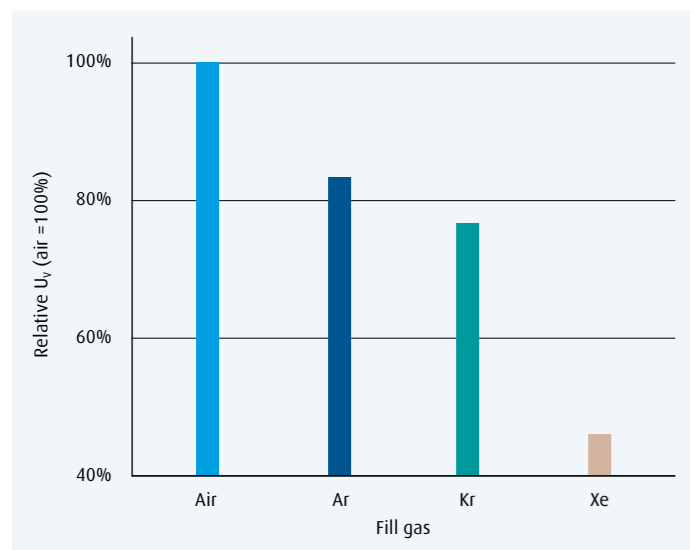
Coating is one of the key growth and differentiation factors in the glass industry. For many coating processes, like PVD and CVD, industrial gases are essential.

We deliver the full range of specialty and rare gases and mixtures, including silane, argon, helium and krypton, in the precise volumes and purities you require for smooth coating operations.

Window insulation & lighting.

Improving effectiveness and efficiency with rare gases and innovative mixtures in the purities and volumes you need.

Figure 5: Improved insulation with argon and krypton



Insulating for success

Industrial gases, specifically rare gases, are also an effective way of improving the insulation of windows to improve comfort and conserve energy.

Our HiQ® rare gases are widely used in double- and triple-glazed windows. With its lower thermal conductivity, argon is more effective than air at reducing heat transfer. Krypton and xenon conduct less heat than argon, making them even more effective (see figure 5).

Leading light

We have many years of experience serving the lighting industry, supplying rare gases and innovative mixtures to enable more energy-efficient and brighter light and automotive lamp designs.

Traditional incandescent lamps rely on protective gases such as argon and nitrogen mixtures to prevent degradation of tungsten filaments. Even though incandescent lamps are being phased out in favour of more efficient halogen and gas discharge lamps, industrial and rare gases such as neon, argon, krypton and xenon continue to play a key role in lighting products. We are also a leading provider of high-purity gases and customised mixtures for LED production.





Our supply solutions.

At Linde, we offer a choice of supply modes to suit your individual volume and reliability needs. You can opt for our cylinder, bulk or on-site offering.

Cylinders

For lower-volume or specialty gas needs, we supply your gases in cylinders.

Highlights

- Little storage space required
- Flexibility due to ease of transport
- Cylinder sizes to meet your needs

Bulk supplies

We can supply larger volumes of gases by bulk delivery, either as cryogenic liquids or high-pressure gases for storage on your site.

Highlights

- Little storage space required
- Tank maintained and owned by Linde
- Security of supply with automated tank level monitoring (SECCURA®)

On-site excellence with ECOVAR®

If you need larger volumes of gas, an ECOVAR® on-site supply system is often the best choice. These standardised, modular systems ensure uninterrupted supplies of nitrogen, oxygen or hydrogen. Generally built on your premises, ECOVAR® systems are installed, operated and maintained by Linde in return for a monthly fee.

Large portfolio of ECOVAR® solutions

Available gases	Gas flow	Purity
Nitrogen	10–55,000 Nm ³ /hr	95–99.99999% (=7.0 nitrogen)
Oxygen	200–12,000 Nm ³ /hr	90–99.5%
Hydrogen	15–3,000 Nm ³ /hr	99.5–99.9999%

Benefits of ECOVAR®

- Freedom to focus on core business
- No upfront investment costs
- No operating risk
- No personnel expenditure
- Zero maintenance and service effort

At your service.

We complement the delivery of gases and process technologies with a range of services to make life easier for you. We can help you manage your gas inventory, for instance, and automate your deliveries for uninterrupted operations.

ACCURA® gas management

Our ACCURA® cylinder and bulk gas management service is an Internet-based tracking utility that gives you all the information and tools you need to take complete control of Linde gas assets at your facilities. With ACCURA®, you can view and analyse gas consumption levels and track cylinder movements online at all times.

Highlights

- Reduces internal administration and handling effort
- Improves efficiency and security of supply by supporting planning, controlling and reporting processes
- Provides valuable data on gas consumption over time across locations
- Detects leaks early for improved safety and lower costs
- Improves safety and stock management due to easy traceability of cylinder stocks

SECCURA® automatic gas supply

With SECCURA®, we remotely monitor cylinder or tank pressure at your site, and automatically deliver the required gas, relieving you of checking and ordering tasks.

Highlights

- Increases reliability through automatic gas level monitoring and timely delivery scheduling
- Reduces risk of gas shortages
- Reduces administration costs and effort
- Increases safety due to professional handling of cylinder replacements by Linde employees
- Optimises cylinder stocks

LIPROTECT® services for quality and safety

The safe handling of industrial gases is part of our daily business – and you can benefit from our expertise by using our LIPROTECT® services. This proactive offering focuses on pre-empting and avoiding accidents.

Highlights

- Safeguards against hazards at the workplace
- Plant safety inspections, documentation audits
- Individual safety seminars and training
- Maintenance of gas supply facilities



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