

Technology Centre

Research – Development – Consulting



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The Linde European Technology Centre near Munich

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Hub for the international exchange of experience

The Linde Technology Centre (LTC) houses the activities of the Industrial Gases Division in research, development and application engineering. It collects and passes on the experiences and know-how of our group companies in the application and production of gases and in so far is a hub for the international exchange of experience in the production and use of gases and gas mixtures.

Innovative and practice-driven

Scientists and engineers from various disciplines analyse and evaluate experiences gained from all over the world, thereby coming up with ideas for new technologies and concepts for the practical further development of well-known application and production processes.

The results and solutions worked out by them guarantee the economical and technically optimal use of gases and are made available to our customers world-wide.

Investment in leading-edge experience

In the end the versatility of our industrial gases in a wide variety of fields is the result of systematic development work by round about 180 scientists, engineers and technicians employed in the Linde Technology Centre. Linde has invested a great deal in the LTC and more than doubled its size in the last few years to ensure it can continue to satisfy new demands.

Research and development for increasingly demanding requirements

As one of the leading gas producers in the world Linde traditionally maintains a close relationship with the fields of science, research and industry. Combined with its own extensive know-how, Linde is therefore in a position to develop new gas applications and gas qualities continuously on the basis of practical studies and effective processes.

This also includes the design, construction and testing of specific devices and technical facilities needed for optimal application.

Environmental protection, work safety and quality are important concerns for Linde and close attention is already paid to them in the development stage of products. The DIN

ISO 9001 certification of the complete Industrial Gases Division covers the field of development as well and therefore also the Linde Technology Centre.

Customer service tailored to specific needs

Experienced engineers demonstrate our new gas applications to customers in the Linde Technology Centre. Particular problems being experienced by individual customers are analysed and solutions worked out and then implemented at the customer's plant under actual production-line conditions. Application engineers help on the customer's site to get the best out of Linde gases. After the introduction of a process, Linde offers its customers support in the form of personal advice, a range of services and a complete line of instructional films and working aids.



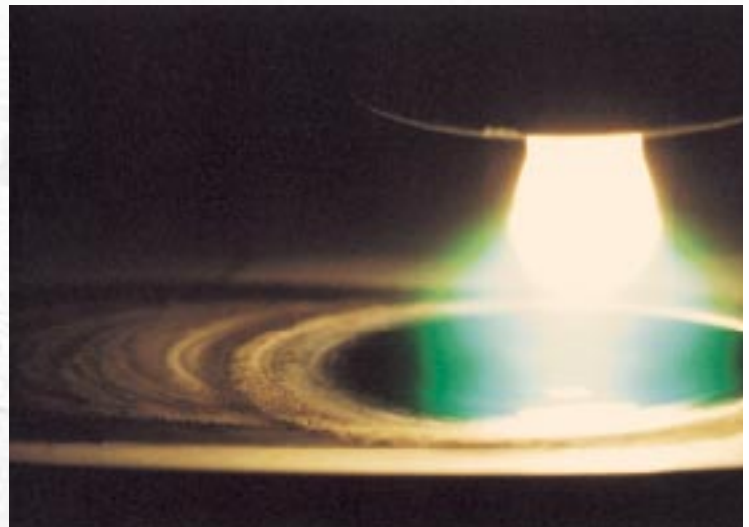
Shielding Gas Welding – a Process with Tradition and a Future

Shielding gas welding is the dominant fusion welding process in use today for the joining of metallic materials. Due to the ongoing development of materials and equipment, this technology still harbours enormous potential.

To ensure it is able to use the possibilities for development in this field, Linde maintains a modern laboratory equipped with the latest apparatus.

Equipment:

- ▷ State-of-the-art MIG/MAG and TIG/plasma-arc welding systems
- ▷ Systems for high-deposition MAG welding
- ▷ 8 axes seam-welding robot with integrated turntable, programmable on 2 axes
- ▷ Instrumentation for process analysis and documentation of welding data
- ▷ Instruments to measure pollutant emissions
- ▷ High-speed framing camera for the investigation of metal transfer under various shielding gases
- ▷ Laser schlieren optics for flow studies on welding torches
- ▷ Orbital TIG welding system
- ▷ Projection equipment for arc display, with laser control of operating point on the volt-ampere curve



TIG arc under helium shielding gas



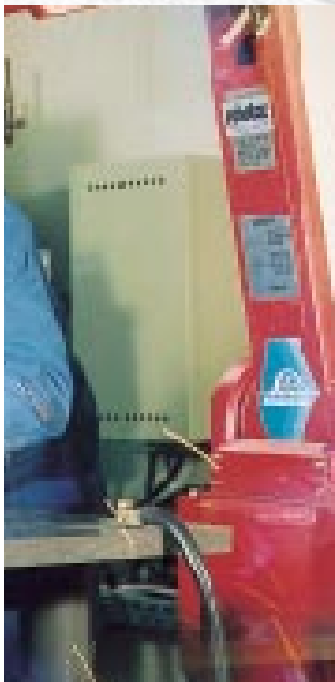
Experimental robot turntable system with 8 independently programmable axes with which overall welding concepts as well as part and torch tolerances are worked out for customers on parts supplied by them



Process analysis of plasma-arc welding involves measuring the welding parameters, displaying them on an oscilloscope and documenting them to assure the user of reproducible results.



A high-speed camera filming the GMAW process at 10,000 frames per second. Metal transfer during welding can be seen in detail when the film is viewed in slow motion.



Macro sections of weld specimens being prepared in the laboratory for wet chemical and metallographic analysis to display and inspect the optimal penetration.

Universal Oxyfuel Gas and Modern Thermal Cutting Processes

Besides modern thermal cutting processes like laser and plasma-arc cutting, the oxyfuel gas cutting process is, in many cases, indispensable. The best and most economical cutting results are achieved with acetylene as fuel gas, which also produces optimal results in many other oxyfuel gas processes.

The Linde Technology Centre is equipped with all the apparatus needed to develop processes and determine performance in these fields of application.

Equipment:

- ▷ CNC cutting machines for studies of oxyfuel gas cutting and plasma-arc cutting
- ▷ Cutting machine with video recording of the cutting process
- ▷ Measuring stand and calorimeter for studies of oxyfuel gas torches
- ▷ Cutting nozzles, torches, fittings, instruments and controls for all oxyfuel gas processes as well as thermal cutting and spraying
- ▷ Test stands for flame-cleaning and concrete-cutting studies



Oxyfuel gas cutting (top) and plasma-arc cutting (bottom) are studied under plant conditions with modern CNC cutting machines.



Underwater plasma-arc cutting test

Special Blowpipes for Acetylene Processes from Development to Installation

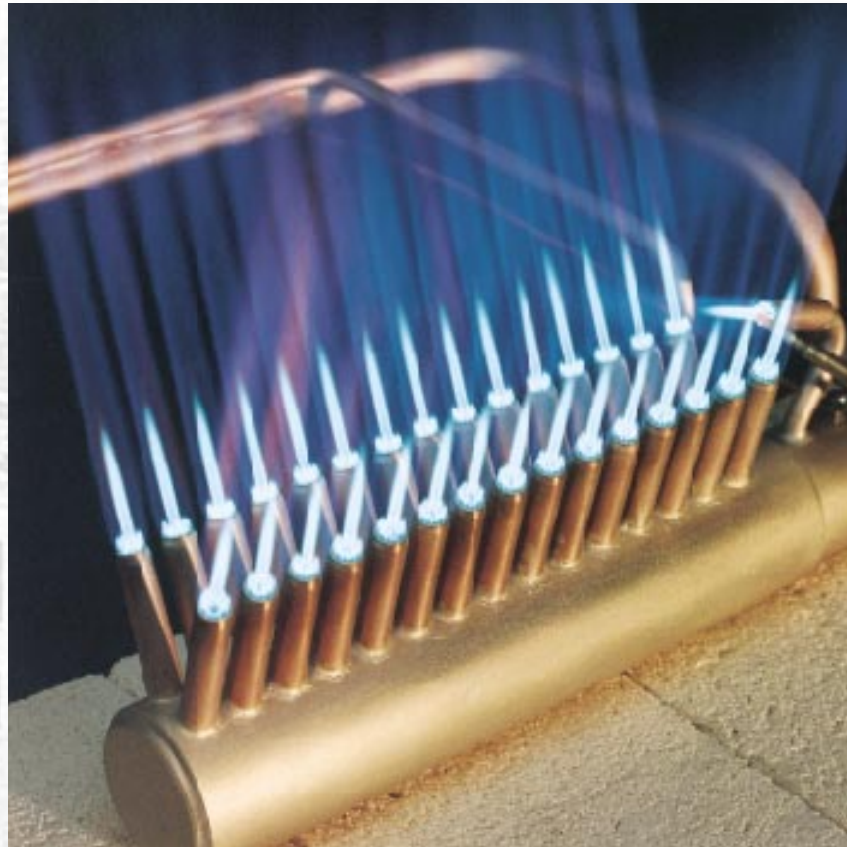
Linde offers a range of special LINDOFLAMM® blowpipes including the necessary controls. The systems are developed, built and tested in the Linde Technology Centre before being installed in the customer's plant. To solve individual problems, Linde designs special LINDOFLAMM® acetylene blowpipes tailored in shape and performance to the specific requirements of the customer.

These special blowpipes are mainly used in flame heating processes (preheating, hot forming and blowpipes fusing), flame straightening, flame brazing and carbon black coating (CARBOFLAM®).

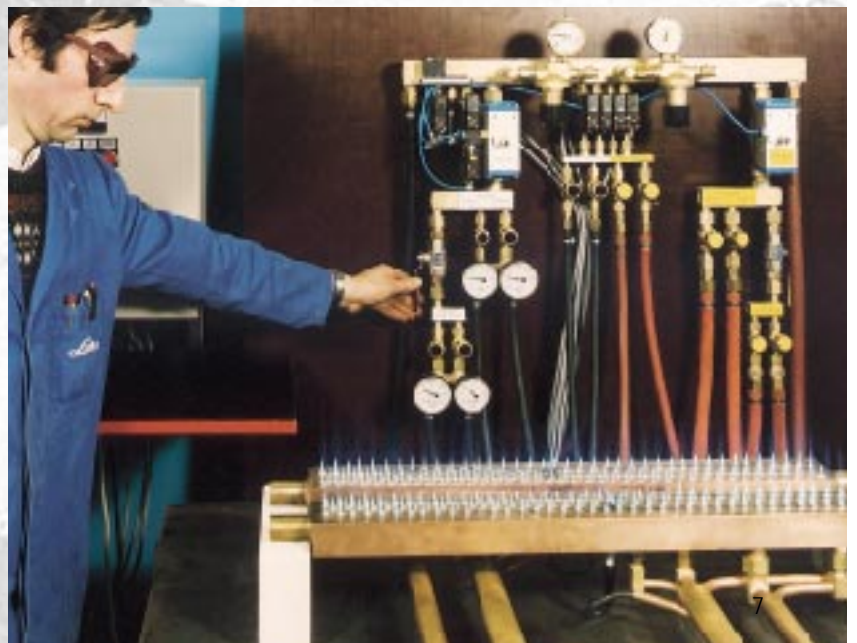
Depending on the process, the blowpipes are equipped for use with oxyacetylene and/or acetylene/compressed air. A distinction is drawn between manually and machine guided blowpipes.

Equipment:

- ▷ Special Lindoflamm® blowpipes and controls for demonstrations, training and customer tests
- ▷ Manifold outlet fittings for the operation of high-performance blowpipes
- ▷ Gas flow meters for fuel gas, oxygen and compressed air
- ▷ Temperature measuring instruments for oxyfuel gas processes, e.g. pyrometers for non-contact measurement



Acetylene/Compressed air preheating blowpipes with pilot flame and flame monitoring



Function check of large special acetylene/compressed air blowpipes with gas fittings and control box

Laser Working of Materials – New Possibilities for Innovations



CO₂ laser cutting machine
used to obtain empirical values for flexible, economical fabrication. Linde has exactly the right LASPUR® working gas for every requirement, be it cutting, welding or surface treatment.

The properties of laser irradiation high intensity and good focussability allow it to be used in many fields of material processing. In combination with a CNC control system and machining centre, an almost infinite variety of shapes from simple planar to complex three-dimensional parts can be processed.

Almost every cutting, welding or surface-treatment job can be performed successfully with the right combination of machine and laser.

Equipment:

- ▷ Laser systems with CO₂ radiation sources
- ▷ Various machining optics for welding and cutting
- ▷ Co-ordinate table with turning gear
- ▷ On-line measurement of laser parameters
- ▷ Measuring systems for operating and working gases
- ▷ CNC programming station
- ▷ Measuring station for quality control
- ▷ State-of-the-art work safety equipment
- ▷ "Laser instruction trail"
- ▷ Nozzle measuring device



Laser-beam welding with LASPUR®-grade helium
(field magnet of an electric motor)

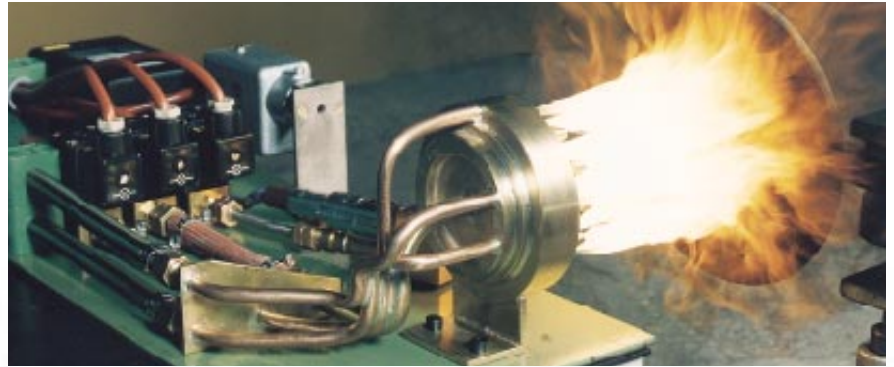


Laser gas supply equipment
This modern equipment in the LASPUR® series is constantly being tested and developed further in the laboratory.

Thermal Spraying (LINSPRAY®) and Carbon Coating (CARBOFLAM®)

Special equipment for carbon coating (CARBOFLAM®)

Linde has developed special torches and controls for the CARBOFLAM® process. Possible applications range from chill and continuous casting to annealing processes and the fabrication of aluminium sections (see photo) or glass containers.

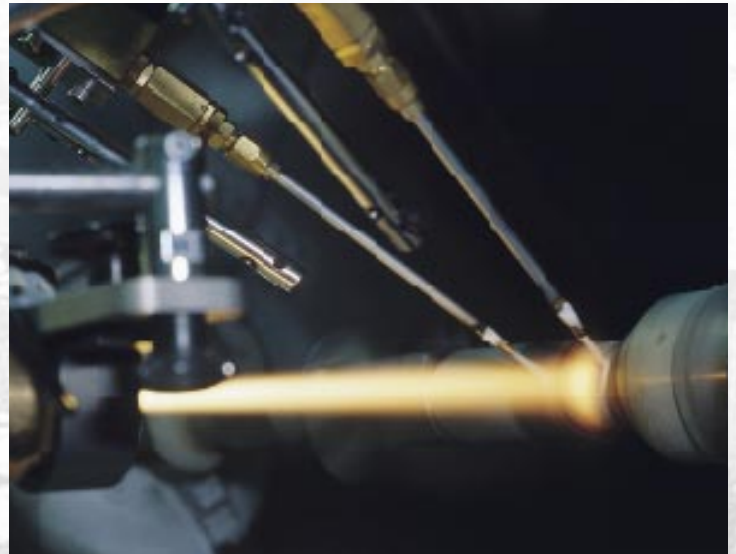


Thermal spraying is future orientated because of its suitability for the cost-effective production of defined surface layers. The various parameters spraying process, spraying materials, base material and gas as source of thermal and kinetic energy open up a multitude of variation possibilities.

CARBOFLAM® enables more uniform, reproducible carbon coating on various shapes. It reduces personnel costs and improves environmental protection and work safety.

Equipment:

- ▷ Laboratory for thermal spraying processes to test and develop various spraying systems:
 - ▷ Flame spraying with wire and powder
 - ▷ Plastic flame spraying
 - ▷ High-speed flame spraying
 - ▷ Plasma-arc spraying
- ▷ 3 axis manipulator
- ▷ Gas supply and monitoring systems
- ▷ Work safety test equipment
- ▷ Fully mechanised and temperature-controlled fusing device



Cooling with CO₂ in flame spraying



Thermal processing of plastic with an oxyacetylene flame. Specially designed spraying systems allow even very low-melting plastics to be worked on with this flame.



Wire flame spraying for the investigation of coating materials with melting points of 400 °C to 2600 °C

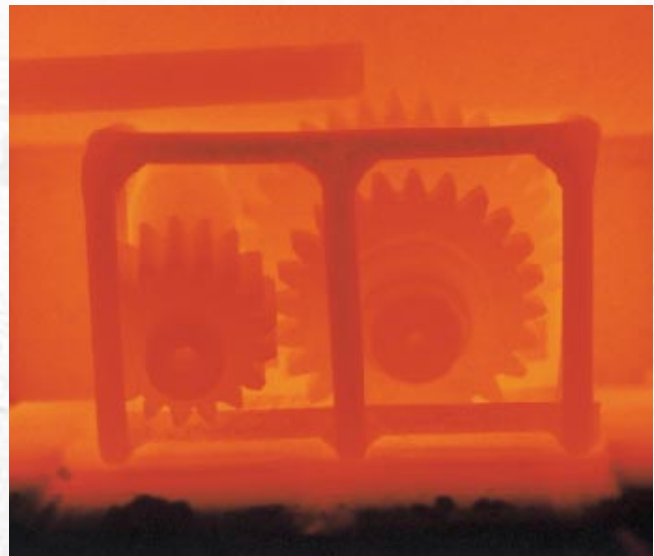
Customised Heat Treatment

Metallic materials can be annealed, brazed or carburised under protective and reactive gas atmospheres. Of importance in these processes are not only the treatment time and temperature profile, but also the composition of the furnace gas atmosphere.

Linde has an excellently equipped laboratory in which practically every gas atmosphere can be produced in various furnaces. This laboratory is the basis for our heat treatment processes Carbothan[®], Carbopuls[®], Carbocat[®], Carboquick[®], Carbomix[®], Hycontrol[®], Hydromix[®] and Hydrozon[®], all of which have won wide acceptance on the market. New heat treatment processes are developed and existing processes adapted to specific customer requirements in this laboratory.

Equipment:

- ▷ Continuous strip, multipurpose batch and retort furnaces with state-of-the-art controls
- ▷ Plasma systems for flux-free brazing of printed circuit boards and cleaning of surfaces
- ▷ Universal gas supply systems for O₂, N₂, H₂, COC₂H₂, CH₄, C₃H₈, CH₃OH, NH₃ and CO₂
- ▷ Analytical instruments for monitoring a wide variety of shielding and reactive gases
- ▷ Computerized process control station for the control and simulation of gas carburising processes



Testing of various reactive gas atmospheres in a multipurpose batch furnace to achieve the greatest possible carburising rate on case-hardening steels.



Heat treatment laboratory in the Application Engineering Centre

Oxyfuel Burners for Combustion Processes

Different melting furnaces may require different oxyfuel burners. Here, an oxyfuel burner with a ceramic quarl for a glass melting furnace.



Oxyfuel combustion increases the production rate, lowers operation costs and reduces pollutant emissions.

Linde develops these burners for various types of furnaces for, among other applications, steel production, foundries, the glass industry and waste incineration. The Linde Technology Centre is equipped with burner test facilities and control systems for oxygen, air and fuel flow rates, furnace temperatures, flue gas composition etc.

Equipment:

- ▷ Burner test facility for the development and testing of oxyfuel burners with various high-temperature combustion chambers and furnaces, oxygen flow runs, fuel flow runs (gas, oil, coal) and safety devices
- ▷ Water and gas-cooled oxyfuel burners (minimized emissions) for gaseous, liquid and solid fuels; capacities from 5 kW to 30 MW (and more)
- ▷ Mobile flow runs for tests at our customers' premises
- ▷ Extensive equipment for flue gas analysis (for O₂, CO, CO₂, H₂, NO, NO₂ etc.)



Standard "tailor-made" burners are available for the production of domestic glassware. Here a burner for edge-smoothing glasses.



Experimental furnace with oxyfuel burner system

Linde BIOSCHUTZ® for Foods and Beverages

Consumers are increasingly demanding that their foods be preserved by natural or semi-natural processes, i.e. without chemical preservatives. Linde BIOSCHUTZ® and Linde process engineering help to retain the quality of foods and simultaneously reduce the use of chemicals.

The apparatus in our food technology laboratory are used to demonstrate processes on food specimens, develop new processes to solve our customers' problems and adapt known processes to specific customer requirements.

Equipment:

- ▷ Cabinet freezers for batch quick-freezing
- ▷ Immersion freezer for quick-freezing experiments
- ▷ Tunnel and spiral freezers for continuous quick-freezing
- ▷ Test chamber for the simulation of freezing processes
- ▷ Experimental tumbler for determination of the optimal parameters for the tumble and coating process
- ▷ Linde BIOSCHUTZ® system for automatic generating of inert-gas atmospheres in storage tanks, e.g. for wine and fruit juice
- ▷ Equipment for packaging of foods under defined modified atmospheres



Type S2 refrigerator developed by Linde for the quick-freezing of food by optimal cold gas circulation



Type L freezing tunnel developed by Linde for the quick-freezing of e.g. meat, fish, breads, pastries, vegetables and fruits. Fast, product-adapted removal of heat guarantees food quality and a high throughput rate.

Cryogenics with Liquid Nitrogen and Carbon Dioxide

Parts of rubber, plastic and rubber/metal combinations usually still have to be deflashed after moulding. The many different stresses the parts can be subjected to and their individual functions mean different levels of deflashing quality are required.

Deflashing by cryogenic embrittlement with liquid nitrogen is increasingly being used because the process is not only inexpensive, but also gentle on the material and environment friendly in addition to producing high-quality results.

Liquid nitrogen is also used for the cryogenic size reduction (e.g. grinding) of material difficult to grind at ambient temperatures, e.g. plastics and spices.

Carbon dioxide also has a firm place in cryogenics. Dry ice pellets can be used to clean surfaces effectively with little detriment to the environment.

• **Cryogenic deflashing Equipment:**

- ▷ Drum system
- ▷ Shot-blast deflasher (basket and belt machines)
- ▷ Oscillating machine
- ▷ Vibration machine
- ▷ Continuous jet-blaster
- ▷ Tyre deflashing machines

• **Cryogenic size reduction Equipment:**

- ▷ Universal mill
- ▷ Hammer mill
- ▷ Pin mill
- ▷ Granulator
- ▷ Turbo mill
- ▷ Cooling conveying screw



Continuous jet-blaster



Experimental and demonstration machine for recovery of valuable substances or contaminants from gas streams (cryogenic condensation with liquid nitrogen).



Surface cleaning with the mobile dry-ice blasting system CryoMax®. Linde's effective and environment-friendly alternative to conventional cleaning processes.

Environmental Protection Processes

Industrial gases from Linde help to protect the environment against pollutants in many ways.

Oxygen, for example, accelerates biological oxidation in wastewater treatment as well as the combustion of solid wastes, while carbon dioxide is used for environment-friendly neutralisation of alkaline wastewaters. The cold of liquid nitrogen can be used to condense volatile reusable substances or contaminants from exhaust air or to separate composites.

Linde AG also works out special solutions for its customers in the field of environmental engineering. The Linde Technology Centre is equipped with a range of experimental apparatus to this end.

Equipment:

- ▷ **O₂ injection systems (SOLVOX®)**
 - Oxygenation mats (SOLVOX®-B)
 - Injector systems (SOLVOX®-I)
 - Oxygen reactors (SOLVOX®-R)
 - Injection nozzles (SOLVOX®-D)
- ▷ **CO₂ injection systems (SOLVOCARB®)**
 - e.g. carbon dioxide reactors (SOLVOCARB®-R)
- ▷ Test equipment for determining the oxygen transfer capacity of various injection systems
- ▷ Condensation units
- ▷ Cooling systems for various applications
- ▷ Analytical instruments for water treatment
- ▷ Modular solvent recovery system
- ▷ Oxyfuel burners for waste incineration



Water tower used to determine the oxygen transfer capacity of various injection systems



SOLVOCARB®-R
Demonstration unit for the neutralisation of alkaline water with carbon dioxide

• Equipment fabrication workshop

The LTC is equipped with an efficient equipment fabrication workshop for the development of processes:

- ▷ Fabrication of experimental devices for research and development projects
- ▷ Development and fabrication of prototypes for technical applications
- ▷ Short-run production of apparatus for specific applications, e.g. deflashing machines, special quick-freezing tunnels, burner systems
- ▷ Production of gas supply systems and instrumentation and control panels

• Metallographic laboratory

Metallographic analyses are necessary for the development of heat treatment and shielding gas welding processes. Our metallographic laboratory is equipped to this end with, for example, apparatus for the following tasks:

- ▷ Preparation of polished micro- and macrosections
- ▷ Visual evaluation of the polished sections

- ▷ Measurement of hardness distribution and hardness penetration depth
- ▷ Determination of carbon concentration distribution

• Laboratory for instrumentation and control engineering and telemetry

Of decisive importance for the economical use of gases is a reliable instrumentation and control system. The instrumentation and controls for specific gas applications are therefore designed individually in our laboratory. The corresponding hardware components are also specified, procured, configured and tested in the Linde Technology Centre.

Parts for instrumentation and control systems that are not available on the market are developed by Linde in the Technology Centre. Examples of this are devices for the transmission of technical data to allow remote monitoring or control of application and gas supply equipment.

The heart of Linde's own hardware for telemetry is the LTG 88, a computer that has been installed in far more than 400 systems for the monitoring and remote control of tank installations, on-site gas production plants, acetylene supply plants, etc.



Fabrication and testing of instrumentation and control equipment

Competence in Ultra-High-Purity Gases and Gas Mixtures

Linde special gases are a group of gases used in technologically demanding industrial processes, research and development, metrology and medicine.

The Specialty Gases Laboratory in the Linde Technology Centre deals with complex gas-specific questions and develops the know-how for a wealth of fields of application.

The resultant products and services fulfil the highest demands with regards to quality and guarantee compliance with customer-specific requirements.



Additional gas purifier

- **Process engineering for ultra-high-purity gases**

Large volumes of ultra-high-purity gases are supplied either by road tanker or, in the case of large-volume users, by way of on-site plants. Linde builds and operates these plants with extreme performance data in which purities of virtually 9.0 (corresponds to 99.9999999 %) are attained.

To improve the quality of the gases further and monitor ultra-high-purity gas streams continuously, additional purification and monitoring concepts are planned and realised.



Test run of a monitoring system for the ppb range with automatic calibration

- **Semiconductor process gases**

Process gases have an active influence on the design of semiconductor materials and must therefore fulfil extreme requirements.

Linde is therefore conducting a series of studies on, for example, the optimisation of containers, gas qualities, detection limits and analytical processes. It is being supported in these studies by, among other institutions, the European development project MEDEA (Microelectronic Developments for European Application).

The results that are obtained are used directly in the supply of these special gases.

- **Residual gas treatment**

Gas cylinders must be emptied properly before being refilled again (or before regularly recurring pressure testing). Various processes are used for this depending on the particular properties of the gas in the cylinders, e.g. recovery, catalytic conversion, adsorption, absorption and neutralisation.

Salvage cylinders are available for the rare instances of a potential danger to the environment (e.g. through leaks). Gas cylinders can therefore be transported and emptied safely.

Linde has been authorised to dispose of gas wastes since May 1995.



Evacuation with a turbo-molecular pump within the frame of cylinder pretreatment



Filling of high-grade steel cylinders

- **Development and production of application-orientated special gases**

Great efforts are required to satisfy special demands for new markets and applications, for example in the development of processes to remove specific interfering contaminants from gases (e.g. in ECD, SFC/SFE). We also work out answers to concrete questions from our customers or arising from new fields of application on the feasibility (and stability) of gas mixture compositions that have not yet been tested.

Test gases are important reference materials for physical analysis. We produce gas mixtures with extremely low tolerances in costly small-scale production for specific customer requirements and use as internal standards.

A scales with a resolution of 3 mg is used to check the weight of a precisely defined mixture.

We also develop special packages for specific fields of application comprising customised gas supply systems in addition to the optimal gases.



Pilot plant for the optimisation of gas purity in the Specialty Gases Laboratory



Exact weight control



Standardised calibration gases also with official test certificate for the testing of the exhaust gases of vehicles equipped with catalytic converter

Competence Where You Need It – With Linde Gases

Know-how
Application and supply equipment

Service
Service on the spot

Advice
Competent, thorough advice

Production
Air separation plant

Supply
Cylinders

Application
Metallurgy and chemistry
Glass
Medicine
Environmental technology
Power engineering
Food processing
Metal working
Industrial cleaning
Microelectronics
ECOVAR®
Pipeline
Tanks

Printed on chlorine-free bleached paper

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Linde industrial gases are used for welding, freezing or driving purposes, and where heating, industrial cleaning, artificial respiration or testing is required. They improve the quality of life, helping you to produce more economically and thus safeguarding your future.

We offer advice, know-how, customer-specific hardware, and carry out tests for our customers and do all the gas-related handling.

It goes without saying that we customize an economic supply system according to customer specifications: Gas cylinders and cylinder bundles, tank supply of cryogenic liquid gases, the ECOVAR® supply system and pipeline supply.



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