

Making our world more productive



# Space

Fueling The Future With Gases,  
Services and Systems Support.





# Linde.

## EXPLORING THE POTENTIAL

Commercial opportunities in space continue to grow. Fueled by new technology and scientific advances, missions to the International Space Station, sub-orbital space tourism rides, deploying sophisticated satellites, discovering galaxies as they appeared at the time of their origins, as well as a new resolve to return to the lunar surface and onward to Mars. All this means launch, component and systems companies will need reliable, cost-effective propellants, launch gas delivery and storage systems from an experienced, single-source supplier. A supplier like Linde.

Linde has over 100 years of gas experience and the resources to supply, operate and manage all the utility, cryogenic propellants, rare gases, additive manufacturing materials and systems you need for all the elements that lead to a successful launch. Linde is a leading global industrial gases and engineering company and offers:

- Product supply consistency and service reliability on a global scale
- Site gas management and supply system support
- Investment-reducing facility leases
- Safety and environmental compliance
- Years of commercial space experience

The results for you are lower cost and less risk because of:

- Optimum cryogenic system design that improves system performance
- Additive manufacturing powders, gases and surface coating services
- Consistent propellant, component gas and liquid launch gas quality
- Reliable delivery, filling and storage expertise
- Plant-to-launch supply focus
- Risk reduction and minimized capital investment

Simply put, Linde offers world-class supply systems and products to meet your local needs. That's because our leadership in producing and supplying industrial gases dates to 1917.

We have Linde Gas and Linde Engineering operations in more than 100 countries as well as five separate research and development centers, including our Tonawanda, NY, and our Munich, Germany facilities each responsible for many of our space advances.

# SINGLE SOURCE CAPABILITIES



*Linde delivery truck and liquid oxygen storage vessel at Kennedy Space Center pad 39B*

## Full Gas Product Line

No matter which propellant or gas you need, Linde's full product line can meet your specifications with:

### Propellants

- Liquid hydrogen
- Xenon
- Liquid oxygen
- Krypton
- Argon

### Gases (pressurizing, inerting, thermal control)

- Liquid and high-pressure gaseous nitrogen
- Gaseous and liquid helium



*Linde's LaPorte, TX hydrogen production and liquifaction plant*

Linde is the largest producer of liquid hydrogen and liquid oxygen in the U.S. with supply centers strategically located close to launch and test centers in areas such as Alabama, Florida, Mississippi, New Mexico, Southern California and Texas.

Linde is also one of the largest helium, krypton and other rare gas suppliers in the world with an in-depth experience designing and operating inerting systems.

We are also one of the largest, globally sourced xenon suppliers with:

- Electronics-grade supply systems
- Advanced cylinder packs and loading cart designs
- Expanding capacity

Linde is a single source for supply and on-site production systems, from design and installation to ongoing operation and maintenance.



*Lockheed Martin thermal vacuum chamber in Littleton, CO (public domain)*

### Complete Supply System Capabilities

Along with our full product line, Linde's comprehensive supply capabilities ensure you receive the propellant or gas you need on time, every time.

For large users, it means on-site production systems. Linde's in-depth expertise enables us to analyze your supply requirements and design the right system for you. To minimize your capital investment, we follow through every stage, from design and construction to start-up. We also oversee ongoing system performance and maintenance.

For small test or launch systems, Linde can design and install systems, saving you time, labor hours and money.

You can also choose from:

- Large-capacity on-site storage
- Bulk liquid trucks
- Liquid oxygen and the only liquid hydrogen railcars in the U.S.
- Gas trailers
- Helium and nitrogen dewars
- Cylinders and loading carts

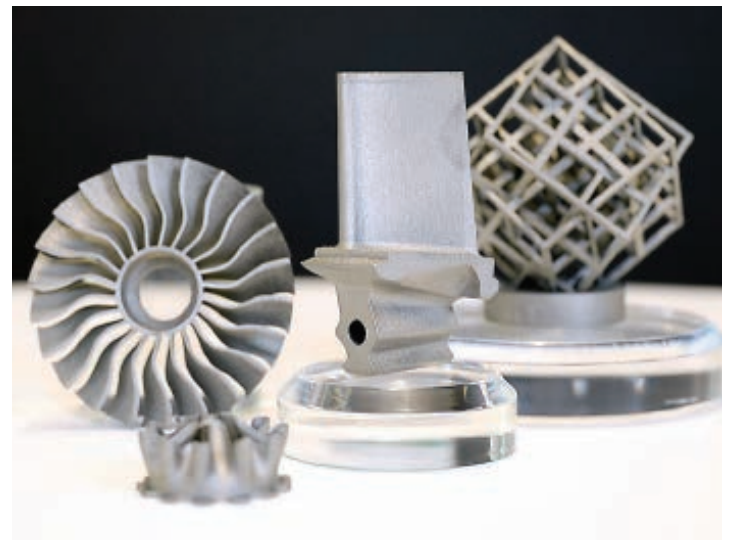
### Supply System Leases

Purchasing costly cryogenic supply systems can be impractical for short-term or experimental uses. Reconditioning used equipment can lead to costly repairs to meet ASME code. Older equipment traditionally has higher losses. Linde supply system leases solve these problems.

Alternatively, we also install new, state-of-the-art systems with low-loss tanks. We maintain them and then remove them when the contract is completed.

### High-Pressure Temporary Systems

Need high-pressure systems to test your components? Linde can reduce your costs with temporary systems for your short-term programs. This includes high-pressure gaseous nitrogen from Linde Services Inc., our wholly owned subsidiary.



*Additive manufacturing can produce detailed components*

### Material Coatings

Coating space components and meeting critical tolerances requires unique capabilities. Linde offers the latest advances — in-house — through Linde Advanced Material Technologies, a business unit developed specifically to serve industries that can benefit from specialized coating services. Behind our cutting-edge equipment, world-class manufacturing (WCM) guidelines and global service is a strong R&D team constantly searching for new techniques and offerings to stay a step ahead of the space demand curve.

# Proud History, Promising Future



*USAF image of a Delta IV-Heavy rocket launch*



## IN-DEPTH COMMERCIAL SERVICES

Complementing our full gas product line and supply capabilities is our available in-depth commercial services.

### Ground Systems Design, Site Gas/Utility Management

Linde does more than design and construct your gas production, storage and delivery system. We also provide on-site management of all your gases and utilities — from electric power and natural gas to clean dry air and water. As one of the largest U.S. commercial purchasers of electricity and natural gas, we can provide the lowest cost power supply, including co-generation. In addition, Linde can:

- Provide pressuring systems to 10K (10,000 psi)
- Contract to optimize designs for development, test and launch systems
- Recommend processes to minimize losses and maintain product purity and deliver sub-cooled or dense liquids
- Manage propellants from production to loading the launch vehicle, so you can focus on the launch at hand

### Process Development

Developing integrated systems that produce, store and deliver the exact quantity and quality of the cryogenics and gases you need is just the start of our process development service. We can also:

- Optimize utilities to minimize your costs
- Develop new fuel mixes

### Safety Reviews

We'll work closely with you to identify potential safety and design issues before they become problems, and then develop the solutions for them. It's a capability developed over more than 100 years of experience with cryogenics and gases, enhanced by an engineering staff that includes hundreds of professionals with a focus on cryogenic and process designs.

# GLOBAL RESOURCES

## Proud History, Promising Future

Supplying the space industry is not new to Linde. Linde-supplied liquid oxygen has supported customers such as the Kennedy Space Center since the Apollo program. Linde has production plants strategically located around large launch and test centers. Linde can also provide onsite production of gases if test and launch centers are not located near Linde supply plants. From portable and temporary supplies, to bulk needs, to on-site production, Linde has it all. And as your business grows, Linde grows with you, to meet your changing needs. That means you can rely on Linde to meet your needs today...and tomorrow.

Commercial opportunities in space exploration continue to grow. Fueled by new technology and scientific advances, missions to the International Space Station, sub-orbital space tourism rides, discovering galaxies as they appeared at the time of their origins, as well as a new resolve to return to the lunar surface and onward to Mars are all in sight. All this means launch, component and systems companies will need reliable, cost-effective propellants, launch gas delivery and storage systems from an experienced, single-source supplier. A supplier like Linde.

*Cover image: Falcon Heavy demo mission launch (public domain)*

Linde  
10 Riverview Drive  
Danbury CT 06810  
Phone 1.844.44LINDE (1.844.445.4633), Fax 1.800.772.9985; 716.879.2040  
[www.linde.com](http://www.linde.com)

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