

Space transportation



Air Liquide, a key partner on cryogenic launchers

Air Liquide has been involved in the Ariane adventure since the first models by providing cryogenic expertise and delivering critical systems (cryogenic tanks & equipment) as well as molecules (over 700 tanks delivered).

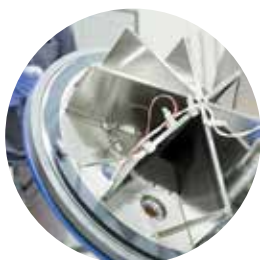
From now on, Air Liquide is also contributing to the production of helium gas pressure regulators and level gauges for different worldwide rocket manufacturers and is participating in the development of LOx/LCH₄ cryogenic tanks for new launchers in Europe.



Air Liquide is developing critical equipment for launchers



High pressure regulation plate



Propellant management devices: level gauges (liquid hydrogen and oxygen), anti-vortex



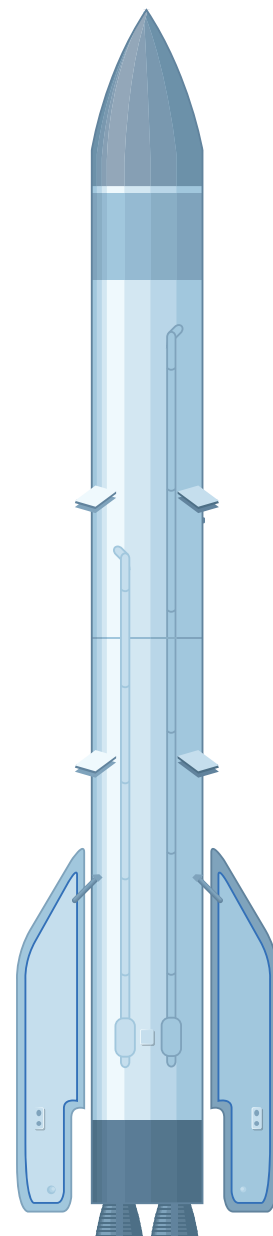
Cryogenic feeding and pressurization lines



Liquid helium tank



LCH₄ / LOx cryogenic tank



Launcher equipment and systems

From the ground operations, flight phases up to long term in orbit storage, Air Liquide helps you to optimize your cryogenic propellant in order to increase your launcher performance.



From design to series production

Cryogenic propellant tanks

- Design and manufacturing of fully functional propellant tanks: liquid hydrogen, oxygen and methane tanks, including functional, thermal and structural aspects
- Design and integration of thermal insulation, propellant management devices, instrumentation, etc.

Pressurization systems and regulation plates

- Cryogenic propellant pressurization systems including pressure / flow regulation and liquid helium tanks
- Pressure regulators according to engine specific requirements

Cryogenic feed lines

- Design, qualification and manufacturing according to stringent launch constraints including anti-vibrating systems
- Optimization of thermal and routing aspects

Instrumentation for cryogenic tanks

✓ Level gauges

High accuracy capacitive or superconductive probes (rigid or flexible), allowing to optimize embarked propellants.

✓ Cryogenic camera

A tool to visualize the behaviour of cryogenic propellants during the different phases of the flight (microgravity, etc.), during ground phases or qualification tests.

✓ Temperature and pressure measurement

Different types of sensors qualified to meet your specific needs: liquid or gaseous measurement, range, reactivity, sensivity.

Propellant management devices

✓ Anti-sloshing

Our device breaks slosh motion during launcher ascent. It reduces liquid ingestion in the pressurization line, ullage pressure variations and solicitation of the attitude control system.

✓ Anti-wetting

To limit propellant losses by vaporization during transient and ballistic phases.

✓ Anti-vortex

To prevent premature gas ingestion into engine turbo pumps. The anti-vortex device minimizes unusable propellant mass.

✓ Propellant management

To obtain the right propellant positioning and characteristics (temperature, liquid state, pressure, etc.) at engine inlet allowing engine reignition after a ballistic phase.



Insulation

Optimization and trade-off between different insulation techniques according to mission profile. Supply of low density, low thermal conductivity, easy shaping insulation, resistant to aerothermal flux and that can be sprayed straight onto the aluminium structure.

- Dacron™ felt
- Closed-cell foam
- Multi Layer Insulation (MLI) for under vacuum tanks
- High performances multi-layer thermal protection systems for ballistic phases or orbital vehicles

Developing new solutions: from preliminary studies to system qualification

Air Liquide supports you throughout the different phases of your project, from design to operation, carrying out studies and analysis, in order to optimize the dry mass of launcher stages, maximize the embarked propellant and reduce the thermal inputs. We contribute to your trade-offs, using methodologies that combine advice, solution design and cost control, with an innovative approach.



Design and engineering

- ✓ Consulting, feasibility studies
- ✓ Definition of specifications
- ✓ Engineering studies to optimize:

- Propellant tank architecture
- Propellant management system
- Cryogenic propellant tank thermal protections
- Propellant pressurization system

✓ Analysis

- Trade-offs between different configurations
- Thermal and functional
- Propellant behaviour prediction inside tank during different flight phases. Prediction through accurate CFD (Computational Fluid Dynamics) analysis and in-house qualified software
- Mechanical justifications
- Post flight analysis



Qualifying complete systems or components through simulation and testing

✓ A large range of tests

Air Liquide can provide a large range of customized tests (mechanical cryogenic tests up to 20 K, cryogenic fluidic behaviour measurement, etc.) to analyse and validate your components, materials or systems under representative space conditions.

✓ Materials

We can characterize your materials (metallic alloys, composites, etc.), or calibrate your sensors at cryogenic temperatures (test specimen being immersed in liquid helium or hydrogen bath).

✓ Large scale tests

We can design, build and operate large structures dedicated facilities to perform customized tests for your systems.

✓ Prototyping

Manufacturing, assembly and tests of prototypes in order to obtain the space qualifications required before producing flight models.

✓ Air Liquide support

To define and select the most appropriate tests according to your specific needs.



Cryogenic propellants supply systems for your launch pads and tests facilities

From propellant production to engine feeding onboard your launcher: Air Liquide can supply a complete solution: engineering of the fluidic supply systems, propellants, operations and maintenance, etc. Air Liquide has more than 40 years of experience in space launch pads infrastructures, with onsite services and operation at Kourou in French Guiana (for Europe) and gas supply for Cap Canaveral (US) and Tanegashima (Japan).



Designing, producing and installing propellant process systems

- Feasibility studies, consulting
- Propellants production (oxygen, hydrogen, methane, etc.)
- Propellants purification to space grade and liquefaction
- Mobile cryogenic storages and transfer lines
- Inerting, cooling down, purging, safety systems, etc.
- Launcher tanks loading, unloading, pressurizing, etc.
- Propellants sub-cooling for densification
- Launcher to ground quick connections and disconnections
- Designing a test bench according to your specific testing need

Operation and maintenance of your cryogenic facilities

- Participation to the preparation activities prior a launch
- Performing testing sequences as per your qualification plan
- Maintaining your cryogenic infrastructures



Gas utilities

High pressure helium or nitrogen networks across your site for inerting or pressurizing purpose air instrument supply.

- Hydrogen and helium liquefaction systems
- Helium vaporization station
- Nitrogen compression station
- Supply of bulk and cylinders gases
- Distribution and storage





Our strengths

- Recognized experience in the space adventure for more than 60 years
- Solid expertise in space cryogenics for ground facilities, launchers and satellites
- End-to-end solutions for your cryogenic propellants: from production to engine feeding onboard the launcher
- Dedicated teams providing support
- Unique cryogenic test center simulating space environment in order to qualify your flight equipment
- Resources of an international group

Air Liquide and space

Since the beginning of launchers with cryogenic stages more than 60 years ago, Air Liquide has been a major partner, bringing to the space community its pioneering spirit, its innovation capacity, its expertise and its technical excellence.

Air Liquide is a key partner for launchers, satellites and space exploration.

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