HYLIAL
Range of automatic hydrogen liquefiers
**HYLIAL** liquefiers is a comprehensive range of hydrogen liquefiers, based on Air Liquide experience on small scale (HELIAL) and large scale helium refrigerator/liquefier (CERN, QATAR, KSTAR, JT-60SA, ITER...).

To simplify matters, all your operations are controlled automatically: compressor management, system cooling, nominal operating conditions and liquefier shutdown.

Our experts can tailor-made the system to meet your specific needs, through a wide range of solutions to fit diverse applications: industry, space, hydrogen energy.

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**Guarantee from a world leader in cryogenics**

Air Liquide is the world leader in gases, technologies and services for Industry and Health with more than fifty years of technical, industrial and commercial experience in mechanical cold production, liquefaction, storage and distribution of cryogenic fluids at very low temperatures: a benchmark in expertise.

**An expertise in hydrogen**

Air Liquide has built up a unique expertise in managing the entire hydrogen chain, covering not only production, distribution, and storage but also its applications right down to fuel cell level.

- **Production**: more than 200 hydrogen units worldwide
- **Distribution**: operation of the largest hydrogen network in the world with more than 1,800 km of pipelines in total
- **Storage**: liquid and gaseous form (more than 1,000 trucks)

All hydrogen equipment are tested in a dedicated hydrogen area on our test center.
The turnkey liquefaction system

Air Liquide offers a comprehensive refrigeration system: compression, refrigeration and distribution.

Legend:
- Basic offer
- Hydrogen
- Optional offer
- Helium

APPLICATIONS
- Industry: liquid hydrogen for industrial processes
- Space: liquid hydrogen for propulsion (test facilities and space launch pads)
- Sustainable energies: hydrogen supply chain and charging stations for Fuel Cell Electric Vehicles (cars, buses, forklifts…)

1. LIQUID HYDROGEN STORAGE

- **Liquid hydrogen storage tank**
  It ensures that the liquid hydrogen produced can be stored, with a static evaporation rate of less than 0.5% per day.

2. LIQUEFACTION

- **Cold box**
  The heart of the liquefaction system, it includes heat exchangers, ortho-para converter, cold adsorbers for helium and hydrogen, turbines and cryogenic valves.

- **Cryogenic transfer line**
  It ensures the transfer of the fluid between the cold box and the storage unit. The length can be adapted upon request.
4. CONTROL

- **Monitoring station**
  You can monitor your liquefaction system remotely and continuously through a network connection. Your system can also be placed under the control of Air Liquide technical team via a remote access, offering monitoring, alarm notification and diagnosis.

- **Gas analysis system**
  Hydrogen and helium can be analyzed continuously at different points in the facility so that any anomaly can be detected.

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**Air Liquide supports you throughout the different phases of design, commissioning and operation of your liquefaction system.**

**Design**
- Support you with designing specifications
- Advice on the choice of components

**Commissioning**
- From monitoring on site equipment installation and connections to complete on site facility implementation
- Start-up supervision and support
- Acceptance tests on-site
- Provision of appropriate fluids for start-up

**Operation**
- Training of operation teams
- Maintenance contract
- Extension of warranty

**After-sales service**
- Technical support
- Spare parts
- Advice and optimization
- Customer network
Key benefits of **HYLIAL** liquefiers

- **High reliability**
  - Improved safety thanks to a helium loop separated from hydrogen circuits
  - Manufacturing quality complies with prevailing international standards and codes
  - Quality assurance system of production processes

- **Easy to use**
  - Automatic and programmable operations, smart supervision system
  - Communication interfaces are user-friendly
  - Remote monitoring

- **High efficiency**
  - Optimized pressure ratio on compressor to achieve higher efficiency
  - Static gas bearing turbo-expanders (up to 82%)
  - LN₂ pre-cooling of the cycle and continuous hydrogen ortho-para conversion, enable you to increase your production of liquid hydrogen

- **Low maintenance**
  - No wearing parts for the liquefier
  - Low maintenance on the compressor
  - Reliability of turbines based on static gas-bearing technology
  - Reliability and robustness of integrated components
  - Continuous self-diagnosis of system so that any breakdowns can be anticipated

- **Controlled operating costs**
  - Minimum consumption of utilities (nitrogen, water, electricity and compressed air)
  - The production of liquid hydrogen can be adjusted to meet your needs
  - Specific training of the team for optimum use of the liquefier
  - Customized support and advice
  - Use of standard equipment on helium circuit (compressor, valve, instruments…)

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**HYLIAL** liquefier is equipped with turbo expanders which constitute the core system of the liquefaction process.

Specifically developed by Air Liquide to operate in harsh industrial environments, our turbines are tested in real conditions on dedicated test benches.

Our turbines use extremely reliable static gas-bearing technology, reaching rotation speeds of up to 300,000 revs per minute with the highest measured on-site MTBF value on the market, namely 150,000 hours.

* Mean Time Between Failures
Main technical features

<table>
<thead>
<tr>
<th>Liquefaction capacities, consumption and dimensions</th>
<th>HYLIAL 600</th>
<th>HYLIAL 800</th>
<th>HYLIAL 1500</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH₂ production</td>
<td>600 L/h</td>
<td>800 L/h</td>
<td>1,500 L/h</td>
</tr>
<tr>
<td>Expected compressor power</td>
<td>550 kW</td>
<td>690 kW</td>
<td>1,260 kW</td>
</tr>
<tr>
<td>Cold Box size (L x W x H)</td>
<td>8.1 x 4.8 x 5.5 m (with gangway)</td>
<td>8.1 x 4.8 x 5.5 m (with gangway)</td>
<td>9 x 4.5 x 5.5 m</td>
</tr>
</tbody>
</table>

Air Liquide references

In 2008 HYLIAL met its first success. The first two HYLIAL 600 (600L/h H₂ liquefiers) started in China, for BLC & Xichang projects, over-performed the required liquefaction rate (+12% measured vs guarantee), resulting in a high customer satisfaction.

Along the years, HYLIAL have demonstrated an easy and safe operation with stable production, even during the H₂ adsorbers’ regeneration phases.

<table>
<thead>
<tr>
<th>HYLIAL</th>
<th>2012</th>
<th>BLC, China</th>
<th>600 L/h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>Xichang, China</td>
<td>600 L/h</td>
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<tr>
<td></td>
<td>2011</td>
<td>Hainan, China</td>
<td>1,500 L/h</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>BLC, China</td>
<td>600 L/h</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Previous H₂ liquefiers</th>
<th>1990</th>
<th>Ariane Space, Guyana</th>
<th>1,375 L/h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1988</td>
<td>Pacific H₂, Japan</td>
<td>850 L/h</td>
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<tr>
<td></td>
<td>1987</td>
<td>Hydrogenal, Canada</td>
<td>6,000 L/h</td>
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<tr>
<td></td>
<td>1987</td>
<td>Wazier, France</td>
<td>6,000 L/h</td>
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<tr>
<td></td>
<td>1977</td>
<td>Iwatani, Japan</td>
<td>760 L/h</td>
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<tr>
<td></td>
<td>1966</td>
<td>Frais Marais, France</td>
<td>600 L/h</td>
</tr>
<tr>
<td></td>
<td>1964</td>
<td>Predictown, USA</td>
<td>3,600 L/h</td>
</tr>
</tbody>
</table>

...and over 30 H₂ liquefiers in several labs (14-40 L/h)

Contacts

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