The world leader in LNG technology, equipment and services

100 LNG plants and still counting…
Air Products LNG specialists: Providing essential services and support

Air Products believes that we can offer you our best by becoming involved in your project at the earliest stage. Our LNG specialists can guide you through comprehensive process scoping studies and preliminary process designs to enable you to develop the soundest design for your facility.

Our process and machinery engineers will then work closely with you to develop a highly optimized liquefaction system that integrates the main cryogenic heat exchanger with the refrigeration compressors and drivers and the supporting process systems. The liquefaction process and main cryogenic heat exchanger are specifically designed for your particular project requirements and plant conditions. Project-specific parameters, such as site ambient conditions, feed characteristics, production requirements, and economic factors, are properly balanced to your requirements to engineer the most cost-effective and efficient system.

Ongoing engineering and technical support

Naturally, you can count on us to give you essential engineering and technical service support, from preliminary design to commissioning and start-up. We’ll be there, too, after your successful start-up. Long-term customer relationships are what we are all about. We are fully committed to helping your facility operate at peak performance. Our ongoing services include:

- Engineering analysis and dynamic simulation of plant systems and operating conditions
- Operator training
- Plant debottlenecking
- Analysis of system modifications and operating improvements
- Maintenance support services and materials
- Assistance in implementing advanced control systems
About Air Products

Air Products provides atmospheric, process and specialty gases; performance materials; equipment; and technology. For over 70 years, the company has enabled customers to become more productive, energy-efficient and sustainable. More than 20,000 employees in over 50 countries supply innovative solutions to the energy, environmental and emerging markets. These include semiconductor materials, refinery hydrogen, coal gasification, natural gas liquefaction, and advanced coatings and adhesives. In fiscal 2012, Air Products had sales approaching $10 billion.

For more information, please contact us at:

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Allentown, PA 18195-1501
T 610-481-4861
F 610-481-6329
info@airproducts.com
Air Products’ experience: leadership in small LNG plant projects

Air Products provided the technology and equipment for these small LNG plant projects.

<table>
<thead>
<tr>
<th>Customer</th>
<th>Location</th>
<th>Liquefaction Capacity (MMSCFD)</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama Gas Company</td>
<td>Alabama, USA (1965)</td>
<td>5 (103 TPD)</td>
<td>Cascade</td>
</tr>
<tr>
<td>Massachusetts LNG</td>
<td>Massachusetts, USA (1973)</td>
<td>8 (165 TPD)</td>
<td>Single MR</td>
</tr>
<tr>
<td>Hopkinton LNG Corp</td>
<td>Massachusetts, USA (1977)</td>
<td>19 (392 TPD)</td>
<td>Cascade</td>
</tr>
<tr>
<td>Cove Point LNG</td>
<td>Maryland, USA (1994)</td>
<td>15 (310 TPD)</td>
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<tr>
<td>Keyspan LNG</td>
<td>New York, USA (2001)</td>
<td>6 (124 TPD)</td>
<td>Nitrogen</td>
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<td>Japex</td>
<td>Japan (2004)</td>
<td>7 (144 TPD)</td>
<td>Nitrogen</td>
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<td>Japex</td>
<td>Japan (2007)</td>
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<tr>
<td>NingXia Hanas LNG</td>
<td>YinChuan, NingXia PRC (2011)</td>
<td>53 (1,096 TPD)</td>
<td>Single MR</td>
</tr>
</tbody>
</table>
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Air Products’ experience:
Leadership in midsize to large LNG plant projects

<table>
<thead>
<tr>
<th>Location</th>
<th>Initial Start-up</th>
<th>Trains</th>
<th>LNG Rundown per Train (mtpa)</th>
<th>Process</th>
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</thead>
<tbody>
<tr>
<td>Libya</td>
<td>1970</td>
<td>4</td>
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<td>AP-SMR</td>
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<td>Brunei</td>
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<td>AP-C3MR</td>
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<td>Abu Dhabi</td>
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<td>1994</td>
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<td>Algeria</td>
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<td>Petronas 9</td>
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<td>1</td>
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<td>AP-N</td>
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<td>Peru LNG</td>
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<td>AP-C3MR/SplitMR</td>
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<td>0.4</td>
<td>AP-SMR</td>
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<td>Shaanxi Yangling</td>
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<td>Total Trains</td>
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<td></td>
<td>93</td>
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</table>
About Air Products

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Air Products’ full range of liquefaction process options:

Supporting all segments of the LNG value chain

<table>
<thead>
<tr>
<th>Production</th>
<th>Liquefaction</th>
<th>Shipping</th>
<th>Regasification</th>
<th>Distribution &amp; Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Air Products is a leading supplier of nitrogen offshore systems, which we have leveraged into offshore natural gas dehydration membrane systems</td>
<td>2. Air Products provides the heart of the LNG liquefaction plant: • LNG process • Key equipment</td>
<td>4. Air Products is a leading supplier of shipboard membrane systems to deliver dry nitrogen</td>
<td>5. Nitrogen plants for Btu adjustment</td>
<td>9. Pipeline purging and pigging services</td>
</tr>
<tr>
<td>3. Air Products provides small nitrogen generators</td>
<td></td>
<td></td>
<td>6. Air Products provides LNG refrigeration for making industrial gas in Asia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7. Air Products provides small scale liquefaction equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8. Express Nitrogen for commissioning and cooldown services</td>
<td></td>
</tr>
</tbody>
</table>
A full range of options

Air Products offers a full range of liquefaction process options to serve the entire LNG industry. Whether you require only a few tons per hour to serve the emerging transportation fuel market or millions of tons per year for export, Air Products has the process and equipment to serve your needs.

Liquefaction Technology

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For information on nitrogen supply systems please contact us at:

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Hersham Place
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Walton-on-Thames
Surrey, KT12 4RZ
England
T +44-1932-249200
F +44-1932-249565

Air Products AS
Vige Havnevei 78
4633 Kristiansand S
Norway
T +47 380 399 00
E-mail norway@airproducts.no

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Small plant and peak-shaving LNG processes:
Designed for simplicity and delivering lower unit costs

Small and peak-shaving LNG plants producing up to 0.5 MTA are being promoted as the way to monetize stranded gas reserves at reduced cost, to replace inefficient aging assets, and to provide fuel for the mining and transportation industries. Air Products helped pioneer the LNG industry, and we have contributed to the success of more LNG operations around the world than any other liquefaction company. Today, we are meeting the need for smaller scale and peak-shaving plants.

Air Products’ LNG processes:
Proven design
No matter how small your capacity requirements, you want the ability to liquefy natural gas on demand. Air Products’ efficient and reliable process designs have proven to be robust and reliable in natural gas liquefaction service. Small liquefaction plants that we manufactured more than 40 years ago are still in service today, with many producing well over their original design capacity.

Nitrogen recycle:
Extensive experience
Air Products has used the nitrogen recycle refrigeration system as the primary liquefaction process in air separation for more than 50 years. These liquefaction systems cover a large range of plant capacities. Air Products also owns and operates over 100 nitrogen recycle (or air recycle) liquefiers. Year in and year out, our system-wide plant availability exceeds 99 percent, while operating and maintenance costs are the industry’s lowest. The high reliability and low maintenance we build into the plants we own and operate carries over to the design practices and equipment selection in plants we build for natural gas liquefaction.

Nitrogen recycle LNG liquefier:
Efficient process design and lower cost
As the world’s leading supplier of LNG technology, Air Products designed and built the first LNG peak-shaving plant in 1965. We have designed and built all major types of LNG liquefaction plants, including cascade, mixed refrigerant, precooled mixed refrigerant, nitrogen recycle, and feed gas expander cycles. Our preferred product offering for LNG liquefaction applications at capacities of 5 MMSCFD to 30 MMSCFD is the nitrogen recycle liquefier. Nitrogen recycle plants in this size offer several benefits:

• Inherently lower capital cost than competing mixed refrigerant technologies while providing comparable energy efficiency
• Simple operation and superior turn-down efficiency
• Nonflammable and environmentally benign nitrogen refrigerant
• Low cost and ready availability of nitrogen
• Modularized design of nitrogen recycle liquefier, with three basic components, minimizes field construction cost

Single mixed-refrigerant process:
An option for enhanced performance

Depending on your project, Air Products’ single mixed-refrigerant (SMR) LNG process may also be an option for your small plant. The AP-SMR process incorporates our unique coil-wound heat exchanger (CWHE), offering an attractive and straightforward solution that minimizes process equipment and provides enhanced performance and reliability. The CWHE can be fully modularized to minimize fieldwork. Air Products' mixed refrigerant process cycles with coil-wound heat exchangers benefit from years of experience and “know-how” gained in the LNG industry.

Air Products’ capabilities:
Comprehensive resources

Air Products is the leader in supplying process technology and equipment to the LNG industry. Air Products has contributed to the success of more LNG operations than any other company and brings its full capabilities to LNG projects of any scale. From peak-shaving plants producing less than 0.1 MTA to the largest baseload facilities, on land or off-shore, our LNG team can help you get a plant up and running at the highest efficiency, on time, on budget, and in any climate. As an owner and operator of hundreds of process facilities worldwide, Air Products can provide full support to the LNG plant owner, including spare parts management, short and long term O&M services, plant optimization studies, and upgrades for existing facilities. If you need LNG production capacity—today or in the future—and you want to obtain it efficiently and cost-effectively, please contact us. We’d love to tell you more.

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Air Products’ floating LNG plant capabilities:
Adapting world-class technology to offshore locations

Air Products’ MCR® main cryogenic heat exchangers and natural gas liquefaction process have become the standard for baseload LNG. Our liquefaction systems are widely used because of their reliability, high efficiency, and operational flexibility. Now, Air Products has tailored the MCR main cryogenic heat exchanger design and developed natural gas liquefaction processes specifically for the unique offshore environment of the floating LNG (FLNG) plant.

Air Products’ LNG technology:
Comprehensive options, customized and optimized

Air Products offers a comprehensive range of natural gas liquefaction technologies to support customer-specific project requirements. Our offerings include various MR and nitrogen refrigerant process cycles, and we provide performance guarantees on LNG production, specific power and quality. Our proprietary liquefaction equipment is robust, reliable, compact and efficient:

- Coil-wound heat exchanger (CWHE) to liquefy and contain hydrocarbons (both LNG and refrigerants) where high thermal transient process conditions prevail
- Companders – compressor loaded, turbo expansion machinery that is ideally suited for nitrogen refrigeration processes
- Cold boxes with plate fin heat exchangers in economizer service, gas-on-gas heat exchange with low thermal transient process conditions

Our engineers can optimize our proprietary equipment and processes to address the full spectrum of economic factors, feed gas compositions, ambient conditions, LNG product specifications and FLNG vessel design constraints.
Air Products’ FLNG Liquefaction Technology

We offer a range of MR and N₂ natural gas liquefaction technologies to meet your requirements.

Offshore installations:

Built on proven success

Air Products’s FLNG offerings are built on more than 40 years of successful land-based LNG projects. We executed a rigorous, 15-year-long FLNG development and marinization program to ensure that our proprietary equipment and liquefaction processes are suitable for offshore conditions. Our FLNG technology reflects the Air Products culture of safety, reliability and operability from more than 60 years of owning and operating cryogenic industrial gas facilities. Our center of technical excellence, located in Allentown, Pennsylvania, USA, provides a centralized point of service.

Air Products’ experience:

A foundation for trust

Air Products is the premier global LNG technology and equipment supplier, with 85 land-based LNG trains in operation, all of which successfully passed their performance test the first time. Air Products supplies FLNG technology and equipment to the first two baseload FLNG projects, Shell Prelude and Petronas FLNG 1, and has participated in seven FLNG FEEDs since 2010.

Air Products’ unique ability to integrate the liquefaction process design and the critical liquefaction equipment leads to an optimization of performance, costs, operability, and reliability that has become the benchmark of the LNG industry. We work with clients from conceptual development through project execution, commissioning and start-up, and continue through the life of the FLNG facility.

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Air Products’ AP-SMR™ and AP-C3MR™ LNG processes: Unlocking the potential for midsize plants

Midsize LNG plants producing from 0.25—2.0 MTA are being promoted as the way to monetize smaller stranded gas reserves at reduced cost. Air Products meets the need for smaller-scale midsize LNG plants with liquefaction processes and equipment designed for simplicity while delivering lower unit costs.

Midsize plants:

Track record of success

While the LNG industry trends in past years have been toward larger plants, it is important to note that a significant number of the operating baseload LNG plants are in the capacity range of the midsize LNG market. Coil-wound heat exchangers in these midsize operating plants have demonstrated high reliability, operability, turndown stability, and productivity for more than 40 years.

Air Products’ LNG processes:

Robust design

No matter how small your capacity requirements, maintaining production is key to a profitable project. Air Products’ efficient process designs, which incorporate Air Products’ coil-wound heat exchanger (CWHE), have proven to be robust and reliable in natural gas liquefaction service. Heat exchangers in the capacity range of 0.25 to 2.0 MTA that Air Products manufactured more than 40 years ago are still in service today, with many producing well over their original design capacity.
Selected mid-scale LNG references

<table>
<thead>
<tr>
<th>Location</th>
<th>Initial Start-up</th>
<th>Trains</th>
<th>LNG Rundown per Train (mtpa)</th>
<th>Process</th>
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<td>Total</td>
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Proprietary LNG process technology:

**Efficient design and lower cost**

For midsize LNG facilities, Air Products’ proprietary single mixed refrigerant (AP-SMR) LNG process, which incorporates our unique coil-wound heat exchangers, offers an attractive and straightforward solution that minimizes process equipment and provides enhanced performance and reliability. Depending on your requirements, our precooled mixed refrigerant processes, such as the propane precooled mixed refrigerant (AP-C3MR), provide an option that enhances efficiency while reducing the overall size of critical equipment. The CWHE can be fully modularized to minimize fieldwork. Air Products’ mixed refrigerant process cycles with coil wound heat exchangers benefit from years of experience and know-how gained in the LNG industry.

**Air Products’ Single Mixed Refrigerant Process**
Your success is our goal:

One system for flexibility and reliability

Air Products designs each plant to handle a wide range of conditions at high efficiency with flexible and efficient turndown capability. When making a technology decision, project developers must investigate all available options and ask whether their choice carries undue operational risks. The coil-wound heat exchanger’s robustness and operability help the LNG liquefier produce LNG as designed and achieve projected project economics. Reliability is the key to a project’s economic success, and the experience and expertise of the process licensor and the contractor are critical to delivering reliable systems that achieve results.

Air Products’ capabilities:

LNG expertise and innovation

Air Products is the leader in supplying process technology and equipment to the LNG industry. Air Products has contributed to the success of more LNG operations than any other company and brings its full capabilities to LNG projects of any scale. From peak-shaving plants producing less than 0.1 MTA, to midsize LNG plants, to the largest baseload facilities, on land or off shore, our LNG team can help you get a plant up and running at the highest efficiency, on time, on budget, and in any climate. If you need LNG production capacity—today or in the future—and you want to obtain it efficiently and cost-effectively, contact us. We’d love to tell you more.
About Air Products

Air Products provides atmospheric, process and specialty gases; performance materials; equipment; and technology. For over 70 years, the company has enabled customers to become more productive, energy-efficient and sustainable. More than 20,000 employees in over 50 countries supply innovative solutions to the energy, environmental and emerging markets. These include semiconductor materials, refinery hydrogen, coal gasification, natural gas liquefaction, and advanced coatings and adhesives. In fiscal 2012, Air Products had sales approaching $10 billion.

For more information, please contact us at:

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Air Products’ baseload LNG capabilities: Leading with strength

Understanding our customers’ specific needs has helped make Air Products the global leader in LNG technology. Working closely with customers and building in-depth knowledge of customer requirements has driven continuous improvement in the LNG technology, equipment, and services we offer. Today, Air Products’ natural gas liquefaction processes and MCR® cryogenic heat exchangers are the world’s standard for baseload LNG.

Air Products’ design and engineering team successfully integrates the liquefaction process design and the mechanical design of coil-wound heat exchangers (CWHE) to achieve performance and reliability unmatched in the LNG industry. In addition, Air Products manufactures and supplies specialty cryogenic machinery and heat exchange equipment integral to our other proprietary processes including the patented AP-X® process for large trains.

MCR liquefaction processes: Optimum production with high efficiency and low CAPEX/MTA

More LNG is produced using Air Products’ MCR mixed refrigerant liquefaction processes than any other process in the world. And for good reason: the LNG industry recognizes that liquefaction processes based on mixed refrigerants are the most efficient. In addition, they have proven to be reliable, flexible, and easy to operate. Air Products invented the propane precooled mixed refrigerant process, which has become the industry standard. To meet your specific liquefaction requirements, we also offer several variations on that process, including dual mixed-refrigerant processes and the patented AP-X system used in the industry’s largest LNG trains.

Air Products capabilities: comprehensive support

We’ll provide a complete range of products and services for the successful design, construction, start-up, and operation of your LNG facility:

- Project development studies
- Detailed process design
- CWHE design and fabrication
- Installation and start-up advisory services
- Technical support services during plant operations

Air Products experience: unmatched in the industry

No company has more experience in the supply of natural gas liquefaction processes and equipment than Air Products. We helped pioneer the LNG industry, supplying our first LNG process and equipment over 40 years ago. You also benefit from our leading-edge commitment to LNG technology. We have spent and continue to spend millions of dollars on research to bring our customers quality, reliability, performance, and the best return on capital.
The AP-X process uses both gas expander and fluid boiling cycles to their best advantage to achieve high efficiency and low cost.

The Air Products advantage:

We build success into your LNG project

Air Products’ technology provides a world of advantages to your LNG project for greater profitability and success, including:

- **Economical production, with**
  - readily available refrigerants
  - large train sizes for economies of scale
  - high efficiency/low feed gas consumption

- **Reliability as a result of**
  - fewer process components
  - proven performance, demonstrated by plant onstream records

- **Operational advantages, including**
  - ease of start-up to minimize the time to achieve full capacity
  - operational flexibility to handle a wide range of feed gas compositions and operating conditions at high efficiency
  - flexible and efficient turndown capability

The result is improved profitability by getting plants onstream sooner and achieving optimum plant utilization with maximum effectiveness. Our experience in LNG technology is unmatched. We’ll put it to work for you.

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Air Products’ baseload LNG technology operating in Nigeria.

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Air Products’ MCR®
coil-wound heat exchangers:
The heart of your facility

The main cryogenic heat exchanger, or MCHE, is the heart of the LNG process. Air Products’ processes for baseload LNG utilize our own proprietary coil wound heat exchangers, which feature a proven and robust mechanical design, along with high quality fabrication critical to the successful operation of the LNG process. No one has more experience in the design and manufacture of coil-wound heat exchangers (CWHEs) for LNG service than Air Products. Since our first CWHE shipment in 1968, we have delivered more than 100 CWHEs to LNG facilities worldwide.

Custom CWHE designs:
Efficiency matched to process requirements

Each coil-wound heat exchanger (CWHE) is custom-designed by our engineers, who are experts in cryogenic liquefaction and engineering and who are dedicated to serving the LNG industry. Our CWHEs contain helically wound tube bundles housed within an aluminum or stainless steel pressure shell designed to retain refrigerants in the event of a shutdown. For LNG service, the heat exchangers may consist of one-, two-, or three-tube bundles, each made up of several tube circuits. With this type of exchanger, the tube circuit areas can be matched to the process requirements. The result is a very efficient and compact design.

MCR cryogenic heat exchangers:
Higher reliability and lower costs

The typical exchanger may be as large as 16.5 feet (5.0 meters) in diameter, 180 feet (55 meters) high, and weigh 500 tons (455 metric tonnes). The large size of the individual heat exchanger tube bundles facilitates the design of large process trains. In addition to providing economies of scale, this leads to simple piping and control systems and, consequently, to reductions in installation, operation, and maintenance costs. Air Products’ MCHEs are of robust design and contain no moving parts, ensuring minimal downtime and long service life. Heat exchangers we supplied more than 35 years ago are still operating, many at production rates well in excess of their original design capacity.
Integrated manufacturing:
No need for aluminum welding at the plant site

We are the world’s largest supplier of baseload LNG heat exchangers. Each CWHE is manufactured by skilled craftsmen at our state-of-the-art facilities in the United States, convenient to U.S. ports of export. We fabricate tube bundles, separators, distributors, piping, and other components and position them within the heat exchanger shell at the manufacturing facility. This enables us to ship each CWHE as a completed unit, so that no aluminum welding is required once the unit reaches the LNG plant site.

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