



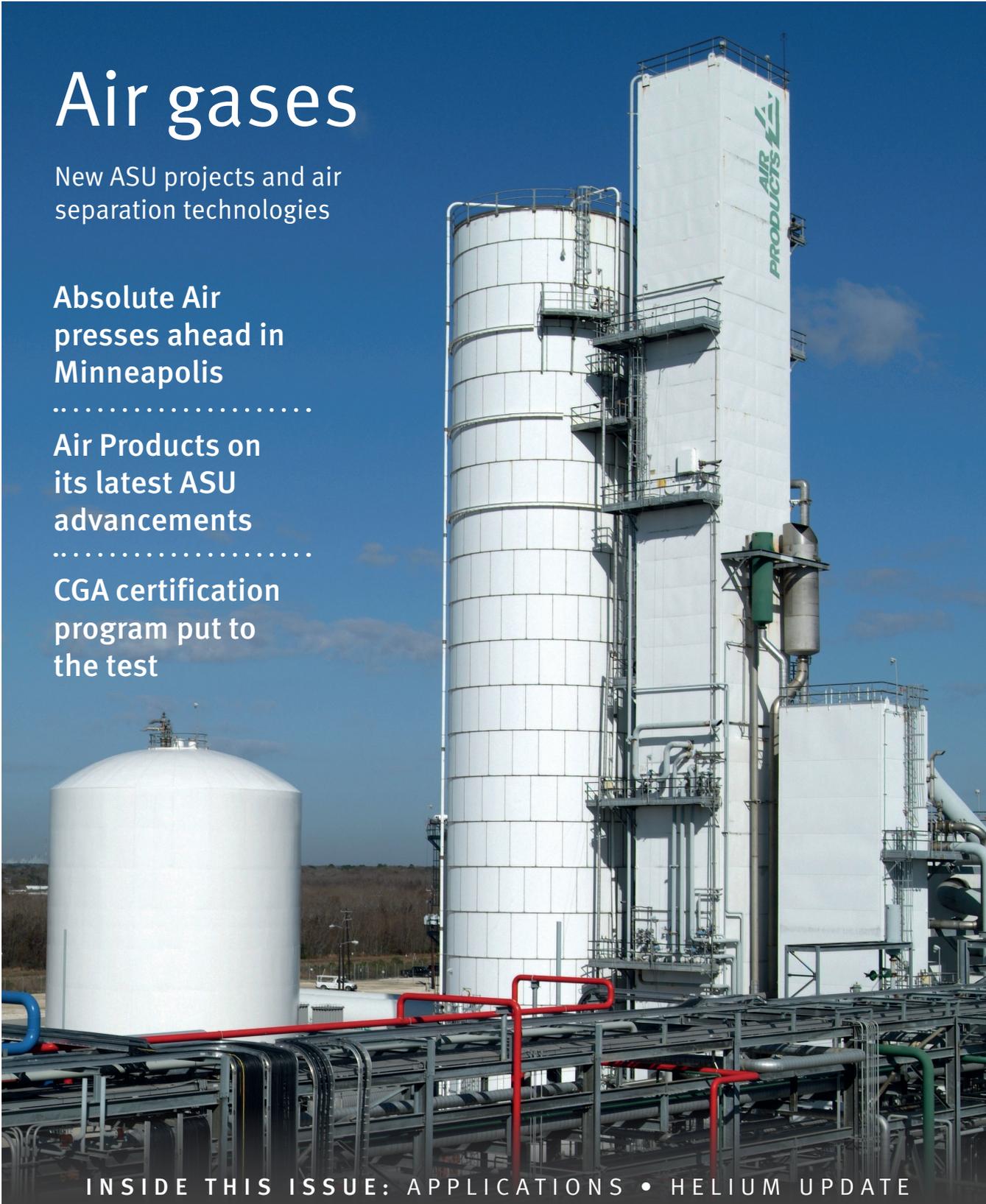
# Air gases

New ASU projects and air separation technologies

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**Air Products on its latest ASU advancements**  
.....

**CGA certification program put to the test**



# Advancing cryogenic air separation

By Air Products' Chris Alsop, Director, Air Separation Unit Product Line,  
and Dr. John Palamara, Director, Air Separation Technology

Cryogenic air separation is at the core of safer, more efficient and sustainable solutions that the industrial gas industry delivers for our world. Air Products founder Leonard Pool revolutionized the industry by developing the “on-site” gas supply model in 1940. Since then, the company has continued to be a pioneer in air separation technology, engineering and plant delivery. As the world demands larger, more efficient plants with ever shorter schedules, the cryogenic technology and engineering at the heart of large-scale air separation must keep evolving to meet these challenges. Building on a long history of cryogenic air separation, Air Products continues to make significant advancements to deliver safety, efficiency and sustainability.

## Delivering for the electronics industry

Air Products is a leading supplier of ultra-high purity nitrogen to the semiconductor industry. This is a challenging market where innovation, high reliability and aggressive schedules are required.

A new trend in gas supply to the semiconductor industry has recently emerged due to an increase in high-purity argon requirements to support growth in pure silicon crystal manufacture. Air Products stayed ahead of this curve by proactively developing a world-scale TN LAR air separation plant design, which uses a proprietary purification technology integrated with the air-drying system to deliver ultra-high purity nitrogen and argon. The TN LAR plant features a proprietary new distillation column packing that is 15% more efficient than previous standards. It also employs the



© Air Products | Air Products' ASU in Odessa, Texas, produces liquid nitrogen and is part of the company's robust supply network serving oilfield services and other industrial markets.

latest Rotoflow® expander technology, benefiting from Air Products' world-class turbomachinery business.

The Rotoflow team, in partnership with the plant engineering team, developed and deployed a flexible, cost-effective cryogenic expander design that operates across a wider range of speeds and operating conditions. When combined, these innovations provide the high reliability required by the electronics industry with schedules that can deliver ultra-high purity gas to new fabs well before their ramp up schedules demand.

In 2018, Samsung selected Air Products to supply multiple trains of the TN LAR to their 3D-VNAND fab in Xi'an, Shaanxi Province, China adding to other Air Products air separation units (ASUs) that have supplied the site since 2014. This was followed by another investment by Air Products in South Korea to build a TN LAR to supply the Samsung semiconductor fab in Giheung, where Air Products has been operating since 1998. An additional plant is being constructed in the US to supply the semiconductor industry, and there are more projects under development.

"The semiconductor industry demands speed, reliability and flexibility to meet its challenging requirements," said Chris Alsop, Director of the Air Separation Unit Product Line at Air Products.

"We must consistently innovate and deliver for our customers in this industry to achieve the success we have with plants like the TN LAR."

#### Improving sustainability

As the world strives for a more sustainable future, Air Products is pushing the boundaries of air separation technology to meet this challenge through innovation. When the Netherlands faced a matter of national energy importance, N.V. Nederlandse Gasunie turned to Air Products to supply three specialized nitrogen generator units. On-stream in 2021, the 180,000 Nm<sup>3</sup>/h of nitrogen from these plants will be used to condition imported natural gas, replacing domestic gas production supplied from its Groningen field.



© Air Products | Air Products built four large ASUs capable of supplying over 10,000 tons per day (tpd) of oxygen, over 6,000 tpd of nitrogen, and over 700 tpd of instrument air for its joint venture coal gasification project with Lu'an Clean Energy, now on stream in Changzhi, China.

"These nitrogen generator units will be among the most energy efficient ever constructed..."

The country has long sourced natural gas from the Groningen field, but increases in seismic activity have resulted in the decision to accelerate the transfer to imported gas. These nitrogen generator units will be among the most energy efficient ever constructed, reducing carbon dioxide emissions by an estimated 21,000 tons per year compared to previous technology. This is made possible by a new process design and improvements in compression efficiency. In addition, the ASUs are designed to quickly ramp production from a cold start to closely match gas demand and further reduce energy consumption.

A new project in Thailand combines air separation and liquefied natural gas (LNG) regasification to deliver sustainability. In 2019, a joint venture between Bangkok Industrial Gas Company Limited – an Air Products joint venture and the largest industrial gas company in Thailand – and PTT Public Company Limited – the national oil and gas company – along with PTT Group announced their purchase of an Air Products air separation plant to supply

over 1,200 tons per day (tpd) of oxygen, nitrogen and argon in Map Ta Phut Industrial Estate, Rayong Province.

Previously at this site, refrigeration from LNG regasification in the form of cold water had been released into the sea. By using this refrigeration beneficially in the air separation and liquefaction processes, the amount of cold water discharged to the sea is significantly reduced. In addition to the environmental benefits from reducing cold discharged water, this integration reduces the required power for the air separation process, lowering carbon dioxide emissions about 28,000 tons per year. The Thailand project is Air Products' third and most highly integrated LNG-assisted ASU in Asia.

"The technology and sustainable approach that Air Products is delivering for Gasunie and the Map Ta Phut Industrial Estate project demonstrate our commitment to the environment through innovation," said Dr. John Palamara, Director of Air Separation Technology at Air Products. "Superior efficiency, lower emissions and a smaller carbon footprint are at the core of what we do."

#### Designing optimized solutions

Standardization, productization and modularization are trends that can deliver value across projects and geographies. When similar demand patterns arose around the world, Air Products' product and engineering team took advantage by developing a ▶

75K

Six ASUs will supply 75,000 tpd of oxygen and nitrogen to the Jazan complex

▶ standard design for a plant producing liquid oxygen, nitrogen and argon. This design was then deployed to three projects in India, two projects in Algeria, and a project announced for the Twin Cities area of Minnesota in the US.

Designing air separation plants to meet different design codes, climates and shipping restrictions has its challenges, and updating designs for each new requirement adds significant cost. The engineering team at Air Products focused on understanding the requirements for each target geography ahead of design to minimize variations.

Solutions, such as varying the sub-grade of structural steel to achieve design requirements at different ambient temperatures, and seismic and wind conditions, are examples of how decisions were deployed. Shipping restrictions are often a limiting case and can be country or even route specific. To stay within these limitations, pipe spools, support structures and handrails are removed for shipping. For some larger equipment like coldboxes, the designs can accommodate the equipment being shipped in pieces and joined at site. Standardization for strategies of cryogenic air separation plant designs brings the benefits of lower cost and improved schedule.

### Executing world-scale plants

With strategic investments in gasification technology and operating plants, Air Products has become a world-leading gasification company. This builds on the company's leadership in supplying large-scale cryogenic oxygen plants to the gasification industry.

In 2019, Air Products reached mechanical completion of the world's largest industrial gas complex in Jazan, Saudi Arabia. Six air separation units will supply over 75,000 tpd of oxygen and nitrogen to an integrated gasification and combined cycle (IGCC) complex. These mega plants are specially designed with the latest technology to safely and reliably supply the IGCC complex with oxygen for gasification and nitrogen as diluent for the combined cycle units. At peak construction, there were 6,000 people at



© Air Products | Air Products produces equipment used in its industrial gases business at manufacturing facilities in Caojing, Shanghai, China (above) and Port Manatee, Florida, US.

site representing a diverse team from over 30 countries. During the project, the team achieved 25 million manhours worked without a lost time injury.

In 2018, Air Products was awarded a contract to supply syngas to Jiutai New Material Co. Ltd for their multi-billion-dollar mono-ethylene glycol project in Hohhot, China, scheduled to come on stream in 2022. Two large air separation trains that supply oxygen for this project

mark the next generation of oxygen production for gasification.

A patent-pending, new process cycle is used to minimize steam consumption while preserving operating flexibility. An advanced form of radial flow temperature swing adsorption is used to purify the air before entering the cryogenic area of the process. This technology delivers lower pressure drop than alternatives, further reducing energy consumption while minimizing footprint.

As the market moves to larger train sizes to supply oxygen to mega gasification projects, Air Products continues to push boundaries and build on its track record of successful large-scale oxygen plants. Current plant designs range over 5,000 tpd of oxygen. With a manufacturing facility in Caojing, China that is capable of manufacturing and shipping distillation columns that produce more than 7,000 tpd, oxygen plant size can continue to scale with the industry.

“With mega projects like Jazan, Jiutai, and the air separation and gasification facility at our joint venture with Lu'an Clean Energy Company in China, we have demonstrated the ability to successfully design, execute and deliver air separation plants at world-scale,” said Dr. Samir Serhan, Executive Vice President at Air Products.

“This is absolutely essential to meeting the world's ever-growing demand for energy and sustainability.” **sw**



© Air Products | Air Products' ASU in Baytown, Texas, produces merchant liquid nitrogen, oxygen and argon supplying a multitude of industry segments by truck and railcar, along with gaseous oxygen and nitrogen supplied by pipeline to local refinery and petrochemical facilities in the Houston ship channel area.