

# Hydrogen PSA Technology

## Unrivalled Experience



Air Products has participated in the hydrogen business since the 1950s, when we constructed the first two liquid hydrogen plants for the United States Air Force. In addition, Air Products has more than 35 years of hydrogen Pressure Swing Adsorption (PSA) experience.

Air Products currently owns and operates over 200 hydrogen PSAs worldwide. As the world's leading supplier of hydrogen, Air Products has broad experience in the generation and purification of hydrogen and related industrial gases.

PSA technology produces high purity hydrogen from syngas and offgas streams using specialized adsorbents with selective affinity for particular gas species to remove multiple and varied contaminants at ambient temperature. Optimal performance is achieved by simulating the adsorption and regeneration cycles, and by tailoring the mix of adsorbents to each customer's process.



### Air Products' experience includes:

- >3 billion scf/day (>3.3 million Nm<sup>3</sup>/hr) production capacity of H<sub>2</sub>, CO, and syngas
- Extensive experience processing a wide range of feedstocks
- Over 700 miles of hydrogen pipeline servicing the U.S. Gulf Coast, California, and Canada
- Compressors operating in H<sub>2</sub>, CO, & syngas service from 150 to 2300+ psig
- Global engineering and manufacturing capabilities





## Low Total Cost of Ownership

As an owner-operator with more than 1,700 years of combined experience across our fleet of hydrogen plants, Air Products understands the meaning of “total cost of ownership.” Our standard hydrogen PSA offering provides lower operating and maintenance costs through:

- Cutting edge adsorbent technology that with proper operation, experiences no performance degradation and does not require replacement during the life of the system.
- Highly reliable switch valves rated for 800,000+ cycles, easily lasting for a four or five year turnaround cycle.
- Adsorber vessels designed to last the life of the system with only a single mechanical integrity inspection recommended at half-life.
- Advanced feed-forward control of the purge and blowdown flows, resulting in a more consistent tail gas composition and reduced excess oxygen requirements when sent to the burners.

## R&D Capabilities

- Laboratory results validated with commercial hydrogen PSA operating data
- Dynamic modeling and characterization of adsorbate/adsorbent interactions
- Simulation of customer feed conditions and testing in Process Design Unit (PDU)
- Ongoing development of new and improved adsorbent designs



## Operating Experience

Air Products’ owned and operated PSA units demonstrate >99.8% aggregate on-stream reliability and are continually improving. Air Products’ sale of equipment hydrogen PSAs offer the same high reliability through:

- Continuous feedback from global Operations and Site Services teams
- New cycle development and system performance upgrades
- Advanced control systems and seamless integration with a range of control platforms
- Rigorous quality control and validation of equipment manufacturers

## Design Considerations

Each Air Products hydrogen PSA design is customized to meet, or likely exceed, the minimum purity, recovery, and reliability targets given each customer’s unique feed characteristics.

- 4, 6, 8, 10, and 12-bed standard product offerings that can efficiently meet any capacity requirements
- Product flows ranging from less than 100,000 scf/day to more than 150 million scf/day
- H<sub>2</sub> product specification:
  - Up to 99.999% H<sub>2</sub>
  - Impurities at ppm levels
- Product pressures from 100 to 500+ psig
- Range of contaminants including CO, CO<sub>2</sub>, H<sub>2</sub>O, N<sub>2</sub>, Ar, H<sub>2</sub>S, and hydrocarbons
- Low or high pressure tailgas
- Better than 50% turndown
- Reduced Bed Mode (RBM) standard
- Small footprint
- Minimal pressure drop





## Aftermarket Support and Services

Air Products provides the following services for its own hydrogen PSAs, as well as any other PSA operating today:

- Routine maintenance
- General troubleshooting
- System performance measurement, modeling, and optimization
- Technical training
- Switch / control valve repair, replacement, and consultation
- Vessel inspections
- Adsorbent analysis, replacement adsorbent specification, and vessel loading support
- Remote monitoring
- Spare parts



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