

THE LINDE GROUP

Linde

Oxygen generation.

By Vacuum Pressure Swing Adsorption.





Vacuum Pressure Swing Adsorption (VPSA) plant in Italy.



Sulfur recovery plants have increased capacity through oxygen enrichment.



The steelmaking process requires oxygen.

Proven technology – tailored to your needs.

Fast, cost-effective oxygen on demand

Demand for on-site oxygen generation solutions continues to rise across a number of industries. Vacuum Pressure Swing Adsorption (VPSA) technology is an increasingly popular way of meeting this demand. VPSA involves separating air into its constituent components by means of adsorption. In other words, the gas molecules bind with adsorbent material at different rates depending on the pressure. This allows operators to single out one particular gas from air. The growth in demand for VPSA technology is largely attributable to its simplicity, reliability and low operating costs.

Experience counts

World leader in adsorption technology, Linde has designed and supplied more than 700 adsorption plants worldwide – including the world's largest units. We also offer the highest availability levels in the industry. Our adsorption systems are therefore the solution of choice where performance, flexibility, availability and reliability are key success factors. High quality and easy accessibility to all components also ensure ease of maintenance.

Adsorption applications

Major applications include the recovery of high purity hydrogen, methane and carbon dioxide as well as the generation of oxygen and nitrogen. Linde oxygen VPSA systems are successfully deployed in industries as diverse as iron and steel, metals, mining, chemicals, pulp and paper, water treatment, glass, food and fish farming.

Large portfolio for all capacity needs

Our VPSA units for oxygen generation come in multiple sizes and shapes to suit individual needs. All systems support on-stream applications requiring gaseous oxygen with purity levels of up to 95%. Capacities scale up to 10,000 Nm³/h (342 tpd) – with one single train.

In addition, we have developed a fully containerised C-series supporting oxygen streams of up to 2,000 Nm³/h (68 tpd). This C-series is ideal for customers looking to combine the benefits of rapid deployment with maximum cost efficiencies.

Advantages. Balancing performance needs with cost constraints.

Our entire VPSA offering is geared towards ensuring the perfect fit for individual application needs. You can rely on our VPSA specialists to recommend the configuration that strikes the best balance between your performance needs and investment constraints. With a VPSA system from Linde, you can look forward to the following benefits:

Right volume and purity on demand

Scaling from 50 to 10,000 Nm³/h (2 to 342 tpd) with purity levels of up to 95 vol.% our plants deliver the precise volume and purity you need – on demand.

Outstanding availability

Offering exceptional availability rates of almost 100%, all of our plants are engineered for excellence, featuring premium components to ensure maximum operational uptime.

Low operating costs

Our VPSA units are designed for the highest levels of energy efficiency, making them a cost-effective option. Ease of maintenance and automated operations further reduce operating costs. A PLC-based control system dynamically adjusts the VPSA process to meet changing purity and flow needs.

Advanced flexibility

Operational capacity can be easily adjusted to the required levels – anything from 0% to 100% is possible. Our plants also start up at the push of a button and are operational within a few minutes. Shut-down is also completed within minutes.

Remote control

To increase manageability even further, our VPSA systems come with an optional dedicated port that can be connected to a plant-wide control system (DCS) and/or a communication board for remote control.

Modular design and prefabricated equipment

Prefabrication of VPSA modules accelerates deployment, reduces installation effort and saves costs. For instance, our valve skids – containing switching and control valves, instrumentation and piping – are preassembled and tested prior to delivery. Our specially designed containerised C-series takes mobility, time efficiencies and cost savings to the next level.

VPSA in detail. How Vacuum Pressure Swing Adsorption works.

Process description

Use of adsorption to recover gases is based on the ability of certain porous materials to adsorb gases through their large surface areas. Individual gases are adsorbed to different extents depending on the pressure and temperature of the feed gas and the selectivity of the adsorbent (see figure 1).

Adsorptive air separation is a periodic batch process, in which adsorbent material is alternately

1. fed with pressurised air to produce the required product, and
2. regenerated by vacuum to remove the residual gases from the adsorbent.

During the generation of oxygen, a cyclic swing between overpressure and vacuum occurs (Vacuum Pressure Swing Adsorption). To reduce energy consumption, the pressure is equalised between the production (overpressure) and regeneration (vacuum) steps.

Each adsorber undergoes a cyclic process, consisting of:

- Adsorption (O_2 production)
- Desorption (evacuation)
- Re-pressurisation (pressure build-up)

Adsorption and regeneration cycles

A VPSA plant is often designed as “2-bed system”. One bed is in the adsorption stage and the other in the regeneration stage (see figure 2).

Adsorption

The vessel (A) in the adsorption phase is fed with compressed process air through an open air valve.

Moisture and carbon dioxide are captured at the entrance zone of the adsorber. Nitrogen molecules are continuously adsorbed, thus separating oxygen molecules from nitrogen molecules. At the discharge side of the adsorber, the dry oxygen flows into the buffer vessel.

Before the adsorbent is fully saturated with nitrogen, the system switches over to the other bed in order to regenerate the saturated adsorber.

Desorption

While the first adsorber is in adsorption stage, the second bed (B) is regenerated by opening the residual gas valve, which is connected to a vacuum pump. This pump draws out moisture, carbon dioxide and nitrogen in the opposite direction to the gas flow in adsorption mode. This residual gas is vented to the atmosphere.

Re-pressurisation

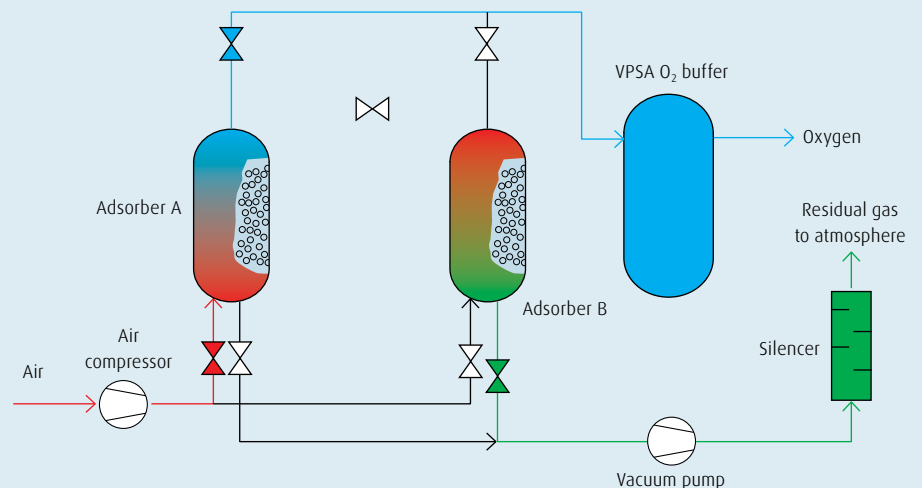
In order to reduce energy consumption during pressurisation of the regenerated adsorber, dry gas from the pressurised adsorber (A) flows to the evacuated adsorber (B). To increase pressure further, the process air blower pressurises ambient air and feeds it into the adsorber (B).

And so the cycle continues.

Figure 1: Ranking of adsorption forces

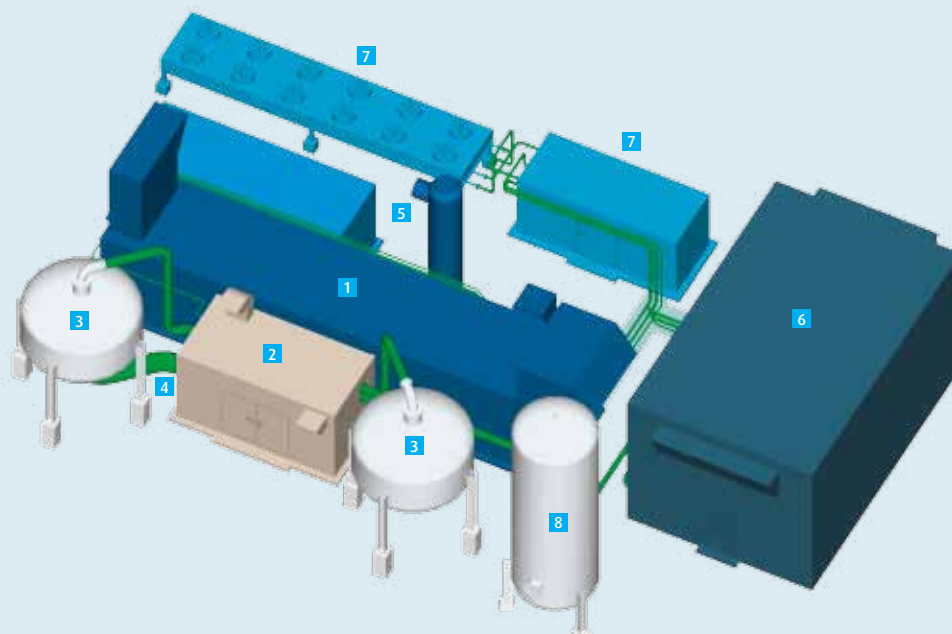


Figure 2: Typical process flow diagram of a Linde oxygen VPSA plant



Containerised VPSA. A prefabricated solution for accelerated deployment and reduced costs.

Figure 3: 3D graphic of a containerised VPSA plant



- 1 Machinery container 2 Valve skid container 3 Adsorption vessels 4 Interconnecting piping 5 Electrical container
6 Oxygen product gas compressor package (optional) 7 Utility container (optional) 8 Buffer vessel

Our C-series "containerised" VPSA plants are designed as highly prefabricated, modularised and cost-effective facilities. The main equipment of the VPSA plant, i.e. the air blower and vacuum pump package, the valve skid and the electrical system, are supplied fully assembled inside hoods or tailor-made containers. Expenses for erection and commissioning of the highly modularised C-series VPSA plant are significantly reduced with this solution. Due to the containerised design of the C-series, a separate machinery building is not required.

1 Machinery container

Including rotary-lobe-type air blower unit and vacuum pump unit with motors, cooler, silencers, valves and instrumentation.

2 Valve skid container

Including process piping, switching and control valves, O₂ analyser and field instrumentation.

3 Adsorption vessels

The system consists of two vertical-type adsorber vessels where the adsorption process takes place. The vessels are designed for outdoor installation.

4 Interconnecting piping

The interconnecting piping between the machinery container, adsorber vessels, valve skid container and oxygen compressor is delivered prefabricated for the installation on site.

5 Electrical container

Including PLC control system, electrical switchgears and Motor Control Centre (MCC).

6 Oxygen product gas compressor package (optional)

Including motor, coolers, pulsation dampers, valves and instrumentation. It is skid-mounted and designed as an oil-free, dry-running compressor, driven by an electric motor.

7 Utility container (optional)

Including the instrument air station and the closed-loop cooling water system.

8 Buffer vessel

The buffer vessel downstream of the adsorbers ensures a continuous supply of oxygen.

"Understanding our customers' needs, offering a value-creating solution and executing are key capabilities at Linde Engineering."

Jürgen Nowicki
Managing Director
Member of the Board of Directors
Linde Engineering Division

Read more:
linde-engineering.com/adsorption

Linde's VPSA and PSA solutions. A large portfolio to suit individual needs.

To ensure the perfect fit for your specific application challenge and investment budget, we offer two different series of oxygen VPSA units and an additional PSA system for lower capacity.

VPSA – tailored for success

Our VPSA units are extremely energy efficient. Tailored to individual specifications, they offer maximum flexibility. As these units are custom-built, the building and supporting infrastructure are additionally needed at your site.

VPSA details

O ₂ production capacity	300–10,000 Nm ³ /h (10–342 tpd)
O ₂ purity	90–95 vol.%
Vacuum pump	Yes
Containerised units	No

PSA – maximum cost efficiencies

At the entry level, our standard Pressure Swing Adsorption (PSA) system is ideal for low-budget, low-volume needs where liquid oxygen deliveries by truck are not viable. As these systems are not fitted with a vacuum pump, the PSA process is less efficient than that of advanced VPSA systems with vacuum pumps. Ideal for volumes of up to 500 Nm³/h (17 tpd), PSA systems combine the benefits of on-site delivery with minimal capital outlay.

PSA details

O ₂ production capacity	50–500 Nm ³ /h (2–17 tpd)
O ₂ purity	90–95 vol.%
Vacuum pump	No
Containerised units	No



VPSA plant for 2,400 Nm³/h (82 tpd) oxygen product for steel plant in Italy.



Containerised VPSA plant including backup system for 1,500Nm³/h (51 tpd) oxygen for glasswool plant in Germany.

Plant types (VPSA C-series) – volume output varies depending on O₂ purity

Type	CS300	CS400	CS500	CS700	C900	C1200	C1500	C1800	C2300
Flow with 90% purity in Nm ³ /h	390	500	660	920	1,020	1,380	1,820	2,000	2,300
Flow with 93% purity in Nm ³ /h	365	470	620	860	950	1,290	1,710	1,880	2,160
Flow with 90% purity in tons per day (tpd)	13	17	23	32	35	47	62	68	72
Flow with 93% purity in tons per day (tpd)	12	16	21	30	33	44	59	64	68

Flow with 95% purity on request

VPSA C-series – ready to run

Our containerised C-series is designed for ease of operation and service. These completely pre-fabricated units are fully standardised for rapid delivery, installation and commissioning. The container can also be easily relocated. Equipped with a vacuum pump, our C-series offers exceptionally low energy consumption and low maintenance. You can choose between eleven different models to meet your volume and purity needs.

Flexible delivery options to suit your needs

Depending on your requirements, our offering for all plants outlined extends from basic engineering and procurement to full turnkey solutions (EPC). We can also provide engineering for authority approvals.

VPSA C-series details

O ₂ production capacity	30–2,300 Nm ³ /h (10–72 tpd)
O ₂ purity	90–95 vol.%
Vacuum pump	yes
Containerised units	yes

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Collaborate. Innovate. Deliver.

Linde's Engineering Division is a leading player in the international plant engineering business. Across the globe, we have delivered more than 4,000 plants and cover every step in the design, project management and construction of turnkey industrial facilities. Our proven process and technology know-how plays an indispensable role in the success of our customers across multiple industries – from crude oil, natural gas extraction and refining to chemical and metal processing.

At Linde, we value trusted, lasting business relationships with our customers. We listen carefully and collaborate closely with you to meet your needs. This connection inspires us to develop innovative process technologies and equipment at our high-tech R&D centres, labs and pilot plants – designed in close collaboration with our strategic partners and delivered with passion by our employees working in more than 100 countries worldwide.

From the desert to the Arctic, from small- to world-scale, from standardised to customised builds, our specialists develop plant solutions that operate reliably and cost-effectively under all conditions. You can always rely on us to deliver the solutions and services that best fit your needs – anywhere in the world.

Discover how we can contribute to your success at www.linde-engineering.com

Get in touch with our adsorption and membrane plant team:
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Core competencies at a glance

Plant engineering

- Air separation plants
- LNG and natural gas processing plants
- Petrochemical plants
- Hydrogen and synthesis gas plants
- Adsorption and membrane plants
- Cryogenic plants
- Carbon capture and utilisation plants
- Furnaces, fired heaters, incinerators

Component manufacturing

- Coldboxes and modules
- Coil-wound heat exchangers
- Plate-fin heat exchangers
- Cryogenic columns
- Cryogenic storage tanks
- Liquefied helium tanks and containers
- Air-heated vaporisers
- Water bath vaporisers
- Spiral-welded aluminium pipes

Services

- Revamps and plant modifications
- Plant relocations
- Spare parts
- Operational support, troubleshooting and immediate repairs
- Long-term service contracts
- Expert reviews for plants, operations and spare part inventory
- Operator training