Cynara

H_2S and CO_2 separation membranes

For bulk acid gas removal from natural gas

Align with United Nations Sustainable Development Goals 12 and 13—Responsible Consumption and Production; Climate Action

Emissions reduction: Reduce CO_2e emissions by 30%–50% compared with amine sweetening and by up to 18 percentage points compared with other membrane materials

Embodied carbon: Reduce embodied carbon by up to 50% compared with alternative acid gas removal technologies

Applications

Cynara* H_2S and CO_2 separation membranes are used in natural gas processing plant membrane systems with upstream dehydration (e.g., via molecular sieves). They sweeten feed gas at pressures up to 1,050 psi [72 bar] via bulk separation of H_2S and CO_2 and recover natural gas liquids (NGLs). The CO_2 can be used for enhanced oil recovery (EOR) operations or carbon capture and sequestration (CCS). Cynara membranes can withstand NGL-rich conditions, varying feed gas mixtures, H_2S, or a combination of these conditions, which are unsuitable for some other polymeric membranes.

Designs for both new installations and retrofitting of existing plants

Cynara membrane elements can be oriented vertically or horizontally. Vertically oriented elements are available with diameters up to 30 in, enabling significant acid gas treatment capacity. They can be part of the initial design of a natural gas treatment plant. They can also be used to debottleneck an existing amine-based acid gas removal system—or reduce the size of a new one—by introducing a hybrid natural gas sweetening process.

Horizontally oriented Cynara membrane elements are designed to fit in 8-in and 8¼-in tubes built to ASME B31.3 specifications. Designed for retrofitting existing membrane installations to improve separation performance, they have been operationalized in packaging that enables simple plug-and-play replacement of flat-sheet cellulose acetate, hollow-fiber polyimide, and other polymeric membrane elements without infrastructure modifications. They have delivered consistent improvement in production capacity and hydrocarbon retention versus other CO_2 removal membranes during competitive trials and full membrane replacement in existing systems.

How they improve performance compared with alternative polymeric membranes

The asymmetric hollow-fiber membranes enable natural gas treatment facility operators to

- increase feed gas throughput because of the larger surface area per membrane—without increasing infrastructure size, weight, or cost
- improve CO_2 and H_2S removal because the membranes are highly selective for acid gases
- enhance hydrocarbon retention and recover condensing NGLs, boosting profitability
- reduce membrane replacement frequency and further improve profitability because the membranes exhibit stable separation performance over a long period
- pursue CCS for the high-purity CO_2 outlet stream or use it for EOR.

How they work

Cynara membrane fibers are made of a cellulose triacetate (CTA) base material, which—unlike filters—interacts with gas molecules to transport them through the membrane wall, a process called permeation. Each gas component has a specific permeation rate, determined by its ability to dissolve and diffuse through the membrane material. Highly soluble and small molecules (CO_2 and H_2S) permeate faster than large molecules

Cynara Membrane Specifications

Orientation	Horizontal	Vertical			
Nominal OD, in [cm]	8 [20.3], 8¼ [21]	5 [12.7]	12 [30.5]	16 [40.6]	30 [76.2]
Nominal length, in [cm]	54 [137.2]	41 [104.1]	41 [104.1]	72 [182.9]	72 [182.9]
Weight, lbm [kg]	65 [29.5]	20 [9.1]	75 [34]	225 [102.1]	720 [326.6]
Flow configuration	Counterflow	Crossflow	Crossflow	Crossflow	Crossflow

All specifications are subject to change without notice.

Horizontally oriented Cynara membranes are available with 8-in and 8¼-in diameters, suitable for retrofitting existing membrane installations.

(N_2, C_1, C_2, and heavier hydrocarbons). The pressure difference between the higher-pressure feed gas and the low-pressure permeate provides the "driving force" for the membrane separation.

Thousands of these individual asymmetric, hollow fibers are packaged within each cylindrical membrane element. As pressurized feed gas flows along the fiber bundle, the more soluble acid gas components (CO_2 and H_2S) preferentially permeate to the bore side of each fiber, where they are combined. The low-pressure permeate flows out at the end of the fiber and is collected for CCS, CO_2 EOR, or additional processing. The hydrocarbon-rich nonpermeate gas continues through the plant for further processing and sale or direct use.

Using multiple stages and optimized arrangements enables the bulk acid gas removal unit to efficiently handle a wide range of feed gas compositions, flow rates, and operating parameters, such as pressure and temperature. Operation is fully automatic, and the modular system enables operators to add capacity incrementally as well as provide a large turndown capacity.

How Cynara membranes support industry carbon intensity reduction goals

Large-diameter, vertically oriented Cynara membrane elements enable a greatly reduced footprint, which is especially beneficial offshore, where space is at a premium. As a result, embodied carbon decreases by up to 50% compared with alternative acid gas removal technologies.

Using Cynara membranes to replace amine-based acid gas removal units or reduce their size decreases the energy necessary to heat and circulate amine solvents. When combining membranes for bulk removal of acid gases with amine-based acid gas removal for the final polishing stage, a 30%–50% reduction in emissions can be achieved.

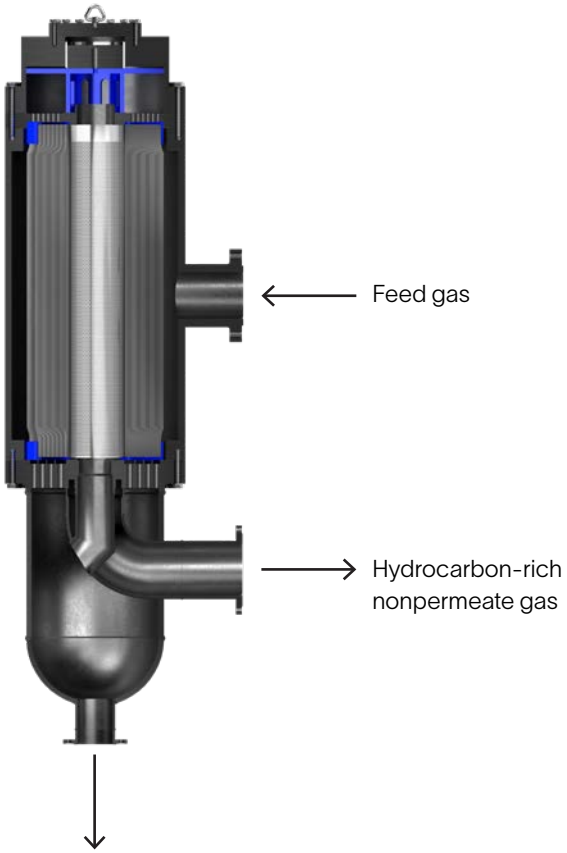
Lastly, the higher hydrocarbon retention provided by Cynara membranes versus alternative membrane materials enables pursuit of CCS for the high-purity CO_2 outlet stream (instead of thermal oxidation of the permeate gas), further reducing emissions intensity.

Added value through nearly 40 years of experience

Since the first installation in 1983, Cynara membranes have established an impressive track record of reliability, operating with minimal downtime and average availabilities up to 99% since startup. SLB designs and provides custom membrane pretreatment equipment, membrane systems, and field operation and support services for energy companies' operating facilities onshore and offshore worldwide. Solutions can address turnkey projects, gas dehydration, liquid hydrocarbons recovery, and acid gas separation. High-capacity projects exceeding 1,200 MMcf/d, with inlet CO_2 concentrations from 5% to 85% and outlet concentrations from 50% to 1.5%, can also be engineered. SLB's ongoing experience enables recommending the most economical and reliable long-term solution, whether it is a stand-alone membrane system or a hybrid system with other gas processing technologies.

By centralizing related services, such as membrane manufacturing, R&D, testing, quality control, and engineering, SLB achieves quality, product availability, economies of scale, and a level of product responsibility that are impossible with an outside supplier or multiple suppliers. Operators benefit from full control of scheduling, continuous quality upgrades, performance enhancements, rapid implementation of new designs, state-of-the-art manufacturing facilities, field-proven expertise, and digital services to assure performance.

Read SPE-211101 to learn about SLB's advancements in CO_2 separation membrane technologies and how they have benefited operators.



Vertically oriented Cynara membranes are available with diameters up to 30 in for enhanced acid gas treatment capacity.

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