PRISM® Membrane Systems For Oil Refinery Applications

AIR PRODUCTS

Air Products' PRISM Membrane Systems are found in many steps of the oil refining process. From refinery off-gas streams to the purge-gas recycle, PRISM Membrane Systems operate efficiently and economically.

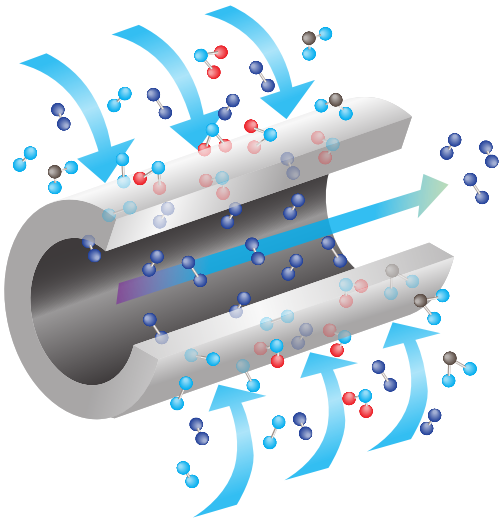
PRISM Membrane Systems use selective permeation to process pressurized gas streams. Applications include: hydrogen upgrading, inert byproduct rejection, hydrogen recovery, and off-gas upgrading.

DESCRIPTION:

PRISM Membrane Systems are a key component in recovering hydrogen within hydroprocessing applications at oil refineries. They reject the inert compounds that build up in hydrogen recycle loops. This means that less manufactured hydrogen is required to maintain the hydrogen balance in the system. By refreshing the hydrogen loop, the process becomes less costly to operate.

Typical PRISM Membrane Systems consist of a pretreatment section which removes entrained liquids and preheats feed-gas before entering the membrane separators. Key process variables include: pressure, temperature, removal of contaminants, and the membrane surface area (determined by the number of separators in the system design).

Various membrane separator configurations are available to optimize purity and recovery. PRISM Membrane Systems are scalable and customizable for specific operating or capital requirements.



How membranes work for gas separation

Gas molecules permeate through the skin of the hollow fiber membrane wall driven by the partial pressure difference. The permeation rate is affected by solubility and diffusion, gas-polymer pairings, and permeation rates of the individual gas components. The greater the difference in permeability, the greater the effective separation.

Membrane separator design

- Easy installation of single membrane bundle in each pressure vessel
- Simple and durable differential pressure seal design
- Axially packed fibers (rather than tightly wound configuration)
- Pressure vessels built to: ASME, PED, GOST, GB, and other international codes
- Available in 4-inch (100 mm) and 8-inch (200 mm) diameter

A PRISM Membrane separator contains thousands of fibers, which are bundled and encased at one end in epoxy resin. The bundle of fibers is inserted in a coded pressure vessel to provide correct flow distribution and pressure segregation.

Air Products' PRISM Membranes:
Unequaled experience, performance, and value.

Membrane arrangement

Series & Parallel

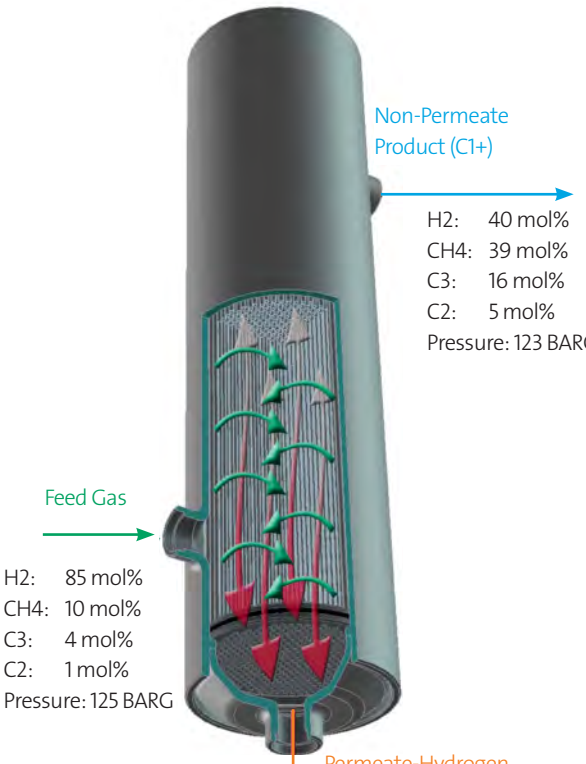
- Series arrangement allows easy capacity turn up and turn down and protects downstream separators from pre-treatment upsets.
- Parallel configurations allow processing of unlimited flow volumes.

How membranes work in refineries

In refinery operations, high value hydrogen is required to perform hydroprocessing. High pressure off-gas is produced from the hydroprocessor (rich in hydrogen but also containing "inerts" such as methane and heavier hydrocarbon compounds). By rejecting the "inerts" the hydrogen stream can be recycled to the hydroprocessor with a smaller makeup volume of hydrogen required to perform the hydroprocessing.

When the feed gas enters the separator, the fast gas (hydrogen) permeates the membrane wall more quickly than the heavier compounds and exits the bore side of the hollow fiber membrane bundle. This purified stream is returned to the hydroprocessor along with makeup hydrogen.

The flow that does not permeate the fibers (non-permeate) also has a hydrogen concentration around 40% but carries the methane and heavier hydrocarbons, which are delivered to the fuel gas network. The hydrocarbons can be recovered by using a simple turbo expander or chilling system.



For flow illustration only and does not represent actual seperator appearance.

OIL REFINERY APPLICATIONS OF PRISM MEMBRANE SYSTEMS

Hydrogen recovery from purge gas

With PRISM Membrane Systems, purge gas streams from hydroprocessing can be upgraded to hydrogen purities of 92 to 98 mol% at recoveries of 85 to 95%. Even catalytic cracker off-gas streams containing 20 to 30 mol% hydrogen can be upgraded to 70 to 90 mol% purity (with a single stage separation) or up to 95 mol% with a two stage system.

Inert byproduct rejection from recycle loops

One approach that improves hydrotreater or hydrocracker performance is to recover high purity hydrogen from the purge for use as incremental makeup. Another approach is to reject the inert byproducts (inerts) from the recycle loop. By rejecting inerts as they form in the reactor, PRISM Membrane Systems produce higher loop purity, greater than using makeup hydrogen alone. Inert byproduct rejection allows the operator to adjust the hydroprocessor to a wider range of feed and product specifications, without concern for hydrogen losses.

Fine tuning hydrogen cascades

PRISM Membrane Systems extend hydroprocessor catalyst life by improving the hydrogen partial pressure in the feed stream. Feed purity is increased to permit higher throughput or severity in an existing hydroprocessor.

In a new hydroprocessor installation, PRISM Membrane Systems recover hydrogen from either the low purity fuel streams or catalytic reformer off-gas.

Hydrogen plant (steam methane reformer)

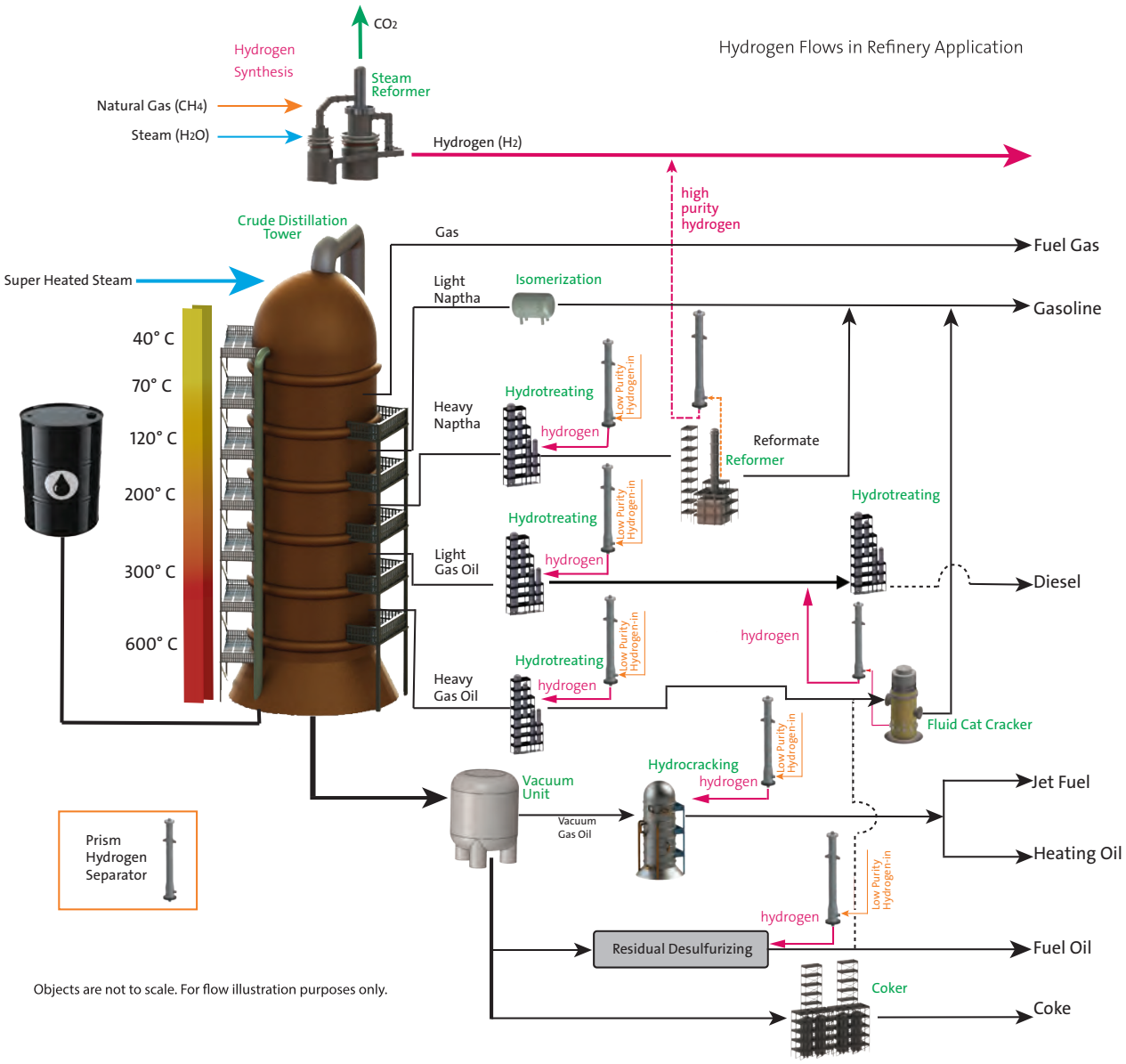
Debottlenecking is accomplished by using PRISM Membrane Systems to recover high purity hydrogen from the steam methane reformer feed-gas. With the hydrogen removed, more hydrocarbons can be fed to the steam methane reformer, thereby increasing hydrogen production.

Gas recovery

The non-permeate gas exits PRISM Membrane Systems with essentially no loss of pressure. With its hydrogen removed, this gas has a high heating value. It can be easily fed into a high pressure fuel header or used as hydrogen plant feed, pipeline gas, or LPG plant feed.

Oil refinery applications of PRISM Membrane Systems

This illustration shows where hydrogen is used at various steps in the refinery. Hydrogen is manufactured using natural gas and super-heated steam. Since the hydroprocessing does not react to completion, each hydroprocessor produces an off-gas stream containing hydrogen. The off-gas hydrogen is captured and upgraded using PRISM Membrane Systems. The recycled hydrogen is then used to supplement or partially replace the manufactured hydrogen supply.



FEATURES:

Flexible

PRISM Membrane Systems provide operating flexibility when planned or unexpected process changes occur. Some turndown is absorbed by the system and increased capacity requirements are met by the addition of more PRISM Membrane Separators. Additional turndown is accomplished by valving off separators to maintain recovery and purity. Multiple takeoffs from the permeate manifold provide streams of different purities and flow rates. PRISM Membrane Systems can be moved to different plant locations because the separator assembly is skid mounted.

Compact

The compact system easily fits into small or crowded plants and will minimize field installation time, expense, and potential construction errors. Site preparation is minimal, requiring only a simple concrete support pad and appropriate process and utility lines. Tie-ins to the pre-assembled system usually require no special shutdown.

Efficient and economical

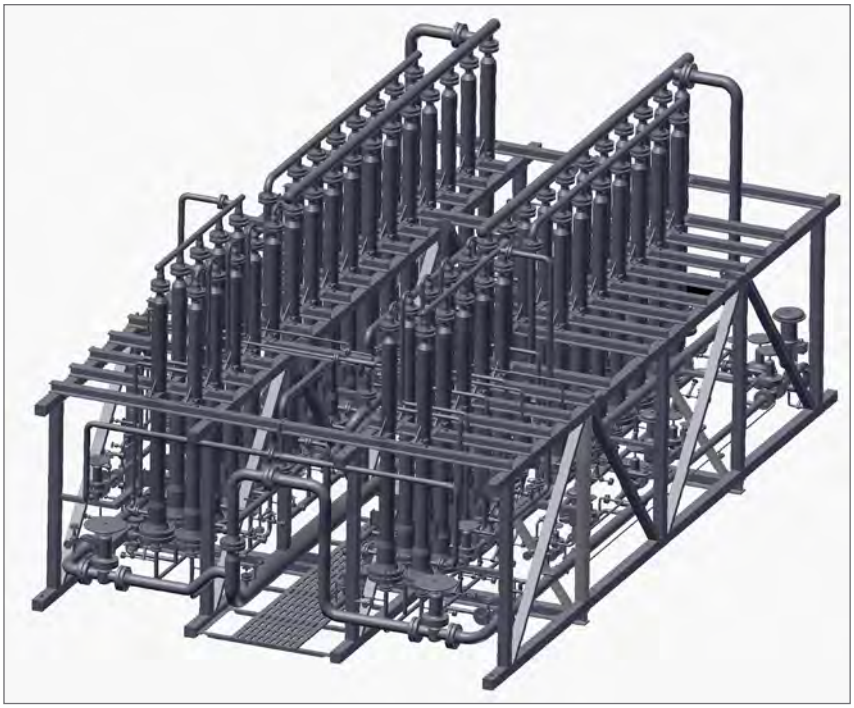
PRISM Membrane systems have high recovery rates for hydrogen and hydrocarbons with efficiencies of 80-95% for most applications. Since the PRISM Membrane Systems operate at essentially the same gas pressures as the refinery operations, there is no need for additional compression energy to drive the separation process. Utility consumption is typically limited to steam (used for temperature control), instrument air, and nitrogen for purging. Additional utilities are required only for applications where sspecialized feed gas pretreatment is necessary. Starting up and shutting down the system is simple and recovery begins immediately.

Low maintenance

The PRISM Membrane separators have no moving parts to monitor, repair, or replace. They are virtually maintenance-free when properly installed and operated within design conditions. PRISM Membrane Systems require no adjustments, maintenance, or operator attention. They will maintain proper operation under varying process conditions and tolerate some contaminants like water, ammonia, hydrogen sulfide, carbon dioxide, hydrocarbons and aromatics.

Long life

PRISM Membrane Systems have been operating in a wide variety of services with an average lifetime of seven years. Over 500 PRISM Membrane Systems have been commissioned globally for process gas applications. These include more than 230 systems in ammonia purge gas recovery, 90 systems in oil refinery applications, 60 systems for carbon monoxide purification, 50 systems for methanol purge gas recovery, and 50 in other petrochemical applications.



Typical oil refinery systems produce hydrogen with purities between 90 to 98 mol%. Product gas purity is dependent upon feed composition, available differential partial pressure and required hydrogen recovery level. The hydrocarbon-rich stream is returned at nearly the same pressure as the feed gas for use as fuel gas.

PRISM Membrane Systems integrate easily into the refinery flow sheet. They are commonly used for hydrogen recovery, inert byproduct rejection, and plant debottlenecking.

For more information regarding Air Products PRISM Membrane Systems for oil refinery applications, please contact one of our technical sales specialists.

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