AIRRANE

Gas Membrane Specialist for Separation

www.airrane.com

ES France - Département Bio-Tests & Industries - 127 rue de Buzenval BP 26 - 92380 Garches
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AIRRANE

AIRRANE is a leading pioneer of innovative membrane solution technology for gas separation. From hollow fiber membrane production to the design, manufacturing and servicing of membrane modules and separation system, AIRRANE's goal is to serve as your one-stop provider of advanced membrane technology for gas separation.

Founded in 2001 as a National Research Laboratory, our growth as a gas membrane specialist has been a journey of ceaseless innovation. Our vision is to build upon our varied portfolio and further develop membrane technology to offer a sustainable energy solution for a better future for all.

1 Material Synthesis & Fiber Spinning

- Polymer Synthesis
- TIPS/NIPS Equipment
- Hollow Fiber Spinning

2 Module Production

- Module Design & Development
- Customization for Integration
- Manufacturing

3 Membrane Separation System

- Feasibility Study
- System Design & Development
- Installation & Optimization
- Testing & Evaluation
- Maintenance

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Why AIRRANE ?

On-Demand Customization

AIRRANE is unrivalled in its ability to provide site-tailored solution regardless of size, quantity or specification requirements. In addition to its wide range of standard products, AIRRANE is always willing to offer customized systems at competitive rates to meet clients' varied needs in a timely fashion.

Proven Technology & Innovation

AIRRANE's solid track record of over 15 years has been built through sustained partnerships with our loyal clients. Endless tests and improvements, combined with continued investment in R&D, have equipped AIRRANE with a strong portfolio of patent-protected products and solutions.

Expert Team - Comprehensive Service

AIRRANE's passionate team of R&D experts (including 4 Ph.Ds) respond to the client's requirements with the very best of their experience and expertise. From the design and manufacturing of fully-tailored solutions to operational training and consulting services, AIRRANE serves as your one-stop provider for all your gas separation requirements.

Local Strength

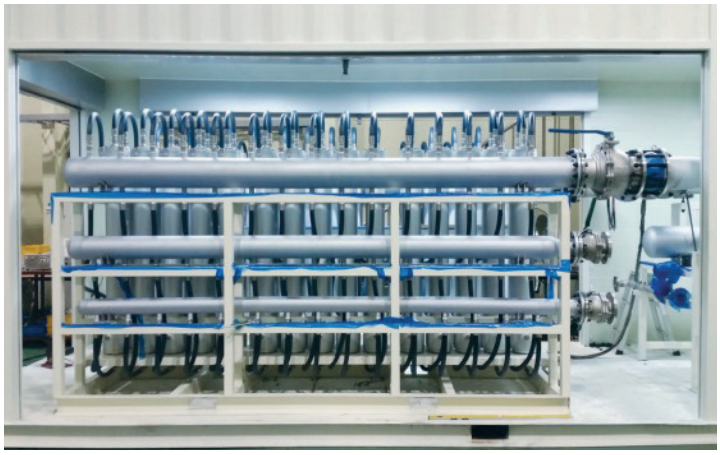
AIRRANE has successfully established its presence in the Asia-Pacific region. AIRRANE's unrivalled understanding and experience of the local market adds to its competitive offering of cost-effective and well-integrated solutions. AIRRANE has exported its products and systems to more than 20 countries, including China, Japan, Australia as well as Turkey, U.K. and the USA.

Quality Assurance

As a result of continued dedication to technological innovation and quality control, AIRRANE's membrane products have acquired performance and quality certifications from leading authorities in Korea and beyond:

- ISO9001/ISO14001 Certificate
- Separation performance of polymer membrane (KOPTRI)
- Separation performance of hollow fiber membrane (KTL)
- Mechanical properties of hollow fiber membrane (KRICT)

In addition, AIRRANE provides year-round technical assistance for all its products and solutions on top of routine inspections and maintenance visits.



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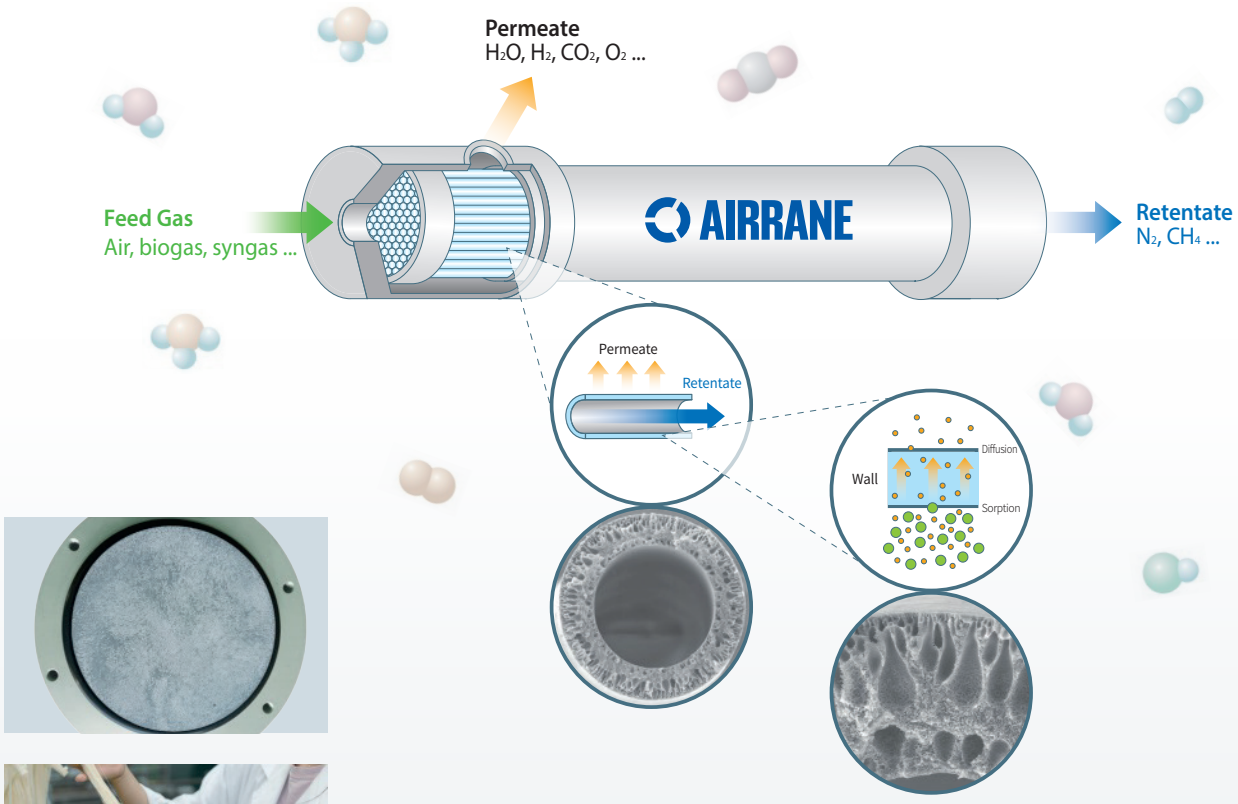
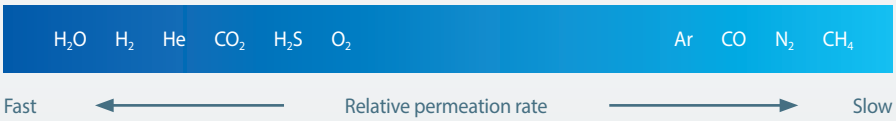
Membrane Technology - Principle





Gas separation membranes are very fine hollow fibers through which different mixtures of gases are fed. As the gases travel through the tubes, a process called selective permeation (Diffusion-Sorption) allows us to separate gases using.

At a closer look, gas separation membrane, the wall of each of these micro-thin hollow fibers, is an asymmetric filter made of various types of polymer. As different gases travel through the fiber, they come into contact with the membrane and permeate through it.

The permeation rate of each gas is determined by its solubility in the membrane material and its diffusion rate. Gases with higher solubility and smaller molecules (fast gases) can pass through the membrane faster than other less soluble gases with generally larger molecules (slow gases).

Gases which permeate faster and more are collected outside of the hollow fiber as permeates while gases which do not permeate so well and stay inside of the fiber until they reach the other end are separated out as retentates. Depending on the properties of the desired gas, either or both of permeates and retentates can be used.

For instance, if we want to separate methane from carbon dioxide for biogas upgrading, we would feed biogas through the membrane filter. Since carbon dioxide (CO_2) permeates through the membrane much faster than the heavier methane (CH_4), we get carbon dioxide 'filtered' out of the membrane fiber as permeate and methane staying inside the hollow fiber as retentate; methane is then collected at the end of the membrane filter.

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Membrane Technology - Benefits

Simple and Reliable Design

- No auxiliary media (water, solvents, etc.) required
- Simple modular set-up without break-in period
- Compact system with low space requirements
- Easy to start and stop operation at short intervals
- Durable module design guarantees long working life even in taxing conditions

Economic Solution

- Simple design reduces mechanical requirements
- Low installation costs
- Short installation time
- Low operational costs
- Low maintenance requirements: time and costs saved

Environmental Friendly Benefits

- Separation at room temperature: low energy consumption
- No phase change
- No environmental emissions (no waste water or absorbent)
- No additional supply materials required: no secondary pollution

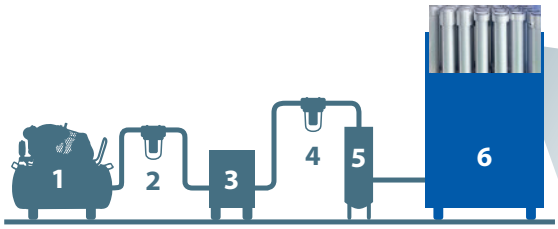
Flexible Application

- Modular design allows easy expansion
- Flexible integration with the main system
- Easy to adjust purity
- Flexible installation positioning

Improved Safety

- No risks associated with handling gas cylinders
- No chemicals required

Membrane Separation Process



1. Compressor
2. Liquid Separator
3. Dryer
4. Coalescing Filter
5. Activated Carbon Bed/Filter
6. Gas Separation Membrane Module

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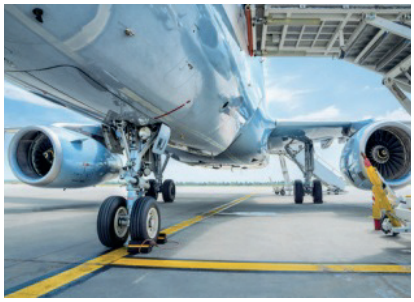
Industries & Applications

Nitrogen Generation

Nitrogen is the most widely used gas in industries; its versatile application ranges from blanketing and inerting to explosion protection. On-Board Inert Gas Generation System (OBIGGS) protects fuel tanks on aircrafts and ships from the risk of fuel vapor explosion by replacing with nitrogen.

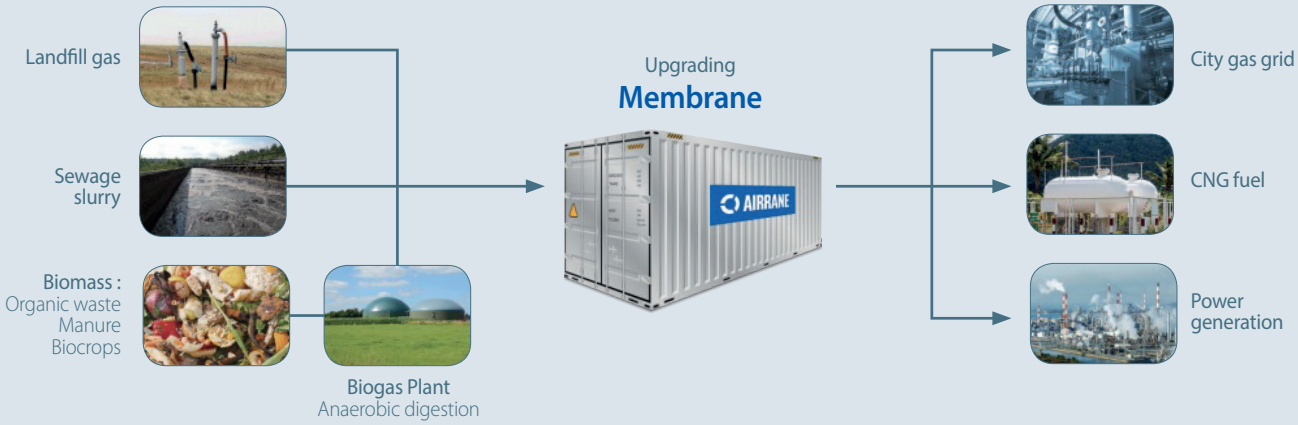


- Fuel tank inerting : OBIGGS
- Shipboard inerting (FPSO, FLNG, LNG Carrier)
- Chemical processing
- Iron/aluminum/copper production and metals processing
- Tire inflation for better maintenance

Biogas Upgrading

Fermentation of biomass such as food waste, slurry and manure produces biogas. Typically, crude biogas is a mixture of about 60% methane (CH_4), 40% carbon dioxide (CO_2), and a small amount of trace gases such as hydrogen sulfide. The pre-treated gas goes through gas separation membrane to yield biomethane of a much higher purity (over 97%) for natural gas grid and CNG vehicle fuel.

- Biogas (from food waste, manure, brewery, farm)
- Landfill gas
- Sewage slurry



Power

Power generation requires a reliable and cost-effective solution for the control of various gases. Gas membrane is a perfect answer for many of those challenges; improving fuel efficiency with oxygen-enriched air, ensuring safety through inerting and purging systems, or reducing carbon emission.

- CO_2 Capture & Storage
- O_2 generation for oxyfuel combustion
- H_2 purification for fuel cell power generation
- Inerting system
- Oxygen removal from steam water

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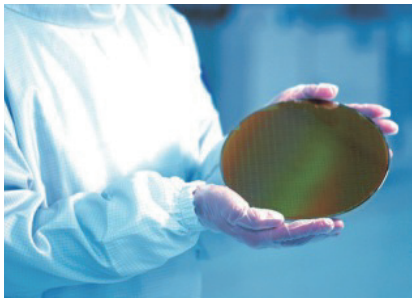
Semiconductor & Display

Semiconductors and display panels manufacturing requires high-purity gas control. Even waste water containing IPA or SF_6 can be treated with gas membrane to produce more concentrated IPA or SF_6 solutions which can be recycled and generate additional revenue.



- IPA/Hydrochloric acid purification for recycling
- Oxygen/Carbon dioxide/Nitrogen controlling for de-ionized (DI) water
- Anti-static treatment for ultrapure water
- Clean room for ultra-fine dust removal

Food & Beverage

Long-distance transportation and prolonged shelf life requirements have made nitrogen an essential part of the food and beverage industry. AIRRANE is also working to provide solutions which control a variety of gases to revolutionize the taste of our everyday drinks.

- Modified atmosphere packaging (MAP)
- Storage tank blanketing and water treatment
- Controlled atmosphere transport and storage
- Carbonation for Bag-in-Box Beer
- Nitrogen coffee/beer
- Sparkling wine

Health Care & Air Quality Control

From humidity control and oxygen generation systems at hospitals to air purifier and oxygen generator at home, an increasing demand for air quality control will be met with gas membranes.

- Air dryer
- Micro dust free air purifier
- Humidity controller
- Portable oxygen concentrator

Oil & Gas

For impurity removal from natural gas to the recovery of hydrogen in oil refinery process, gas membrane offers a cost-effective and energy-efficient solutions for a wide range of applications in oil & gas industries.

Natural Gas
- Nitrogen, CO_2, H_2S removal
- Enhanced oil/natural gas recovery
- Offshore nitrogen generation

Refinery
- Hydrogen recovery from syngas processes
- CO_2 removal from syngas
- Steam generation with enriched oxygen air

Petrochemical
- Hydrogen purification
- Recovery of monomer & solvent from EO, PE, PVC process

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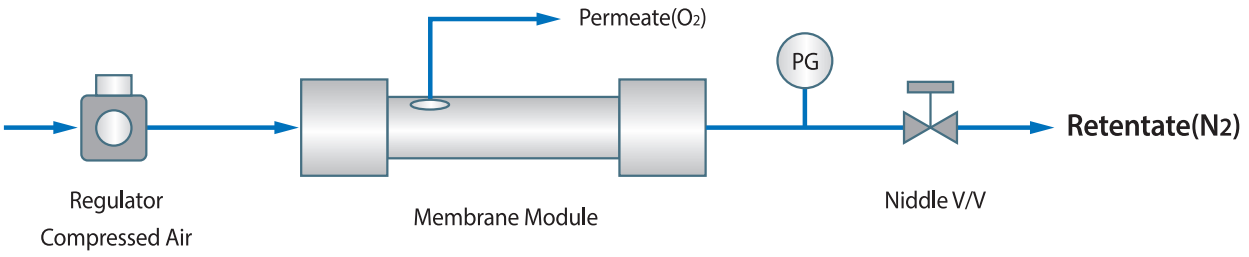
AIRRANE for Nitrogen

Schematic Diagram



Essential to a wide range of industrial processes and mechanical operations, securing a cost-efficient nitrogen gas is often an integral part of system engineering. However, conventional methods such as high-pressure cylinders, liquid tanks and bulk storage involve significant logistical issues and increase costs. Membrane separation presents an economic alternative which enables on-site nitrogen generation from the air we breathe -78% of which is nitrogen at sea level.

Key Applications


Fuel Tank inerting for Aircraft (OBIGGS)


Tire Inflation for better maintenance


Shipboard Inerting (FPSO, FLNG, LNG Carrier)


Fruits & Vegetable Storage


Chemical Processing


Preventing oxidation In manufacturing


LNG Tank Repair, Maintenance


Food packaging

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			Weight
	L	OD	ID	Feed	Retentate	Permeate	
MNO-1512A	359	55	50	3/8"	3/8"	1/4"	0.9kg
MNO-2022A	589	70	60	3/8"	3/8"	3/8"	1.8kg
MNO-2512A	355	85	65	3/8"	3/8"	3/8"	2.0kg
MNO-3032A	856	110	85	1/2"	1/2"	1/2"	6.0kg
MNH-3032A	856	110	85	1/2"	1/2"	1/2"	6.5kg
MNH-4060A	1580	150	114	1"	1"	1"	17kg
MNH-6160A	1580	200	158	1.5"	1.5"	1.5"	29kg

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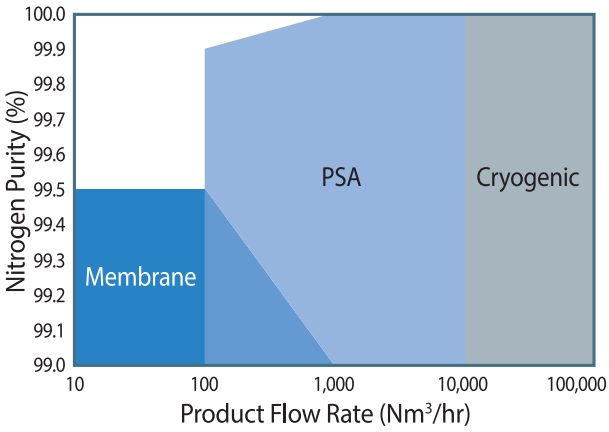
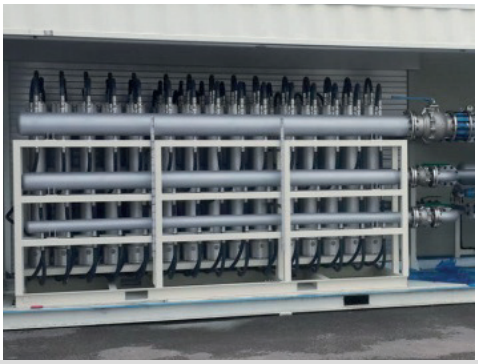
Why Membrane for Nitrogen?

- Only requires compressed air to provide high-concentration nitrogen
- Mobile unit to easily move installation place
- No noise as separation can be carried out continuously
- Compact size only requires minimal space
- Can be installed either vertically or horizontally



Why Membrane for Nitrogen?

Method	Cryogenic	PSA	Membrane
Installation Costs	High	Mid/Low	Mid/Low
Operational Responsive	Irresponsive	Irresponsive	Responsive to operational fluctuations (concentration, flow volume, pressure)
Applications	Large-scale / Fixed	Mid-scale / Fixed	Mid-to-small-scale / Fixed & Mobile
Mobility	Immobile	Immobile	Mobile
Features	• High concentration (99.999%) • Requires high-pressure gas operation permit and qualified operator • Inappropriate for small-scale operation	• Relatively high concentration (98~99.999%) • Requires outdoor tank • Vulnerable to movement or vibration	• Ideal for lower concentration needs (95-99.5%) • Simple and small device • Can be operated unmanned • No risk of explosion • Unaffected by movement or vibration
Product Concentration	99.999%	99.99%	99.5%
Maintenance Costs	Middle	High	Low



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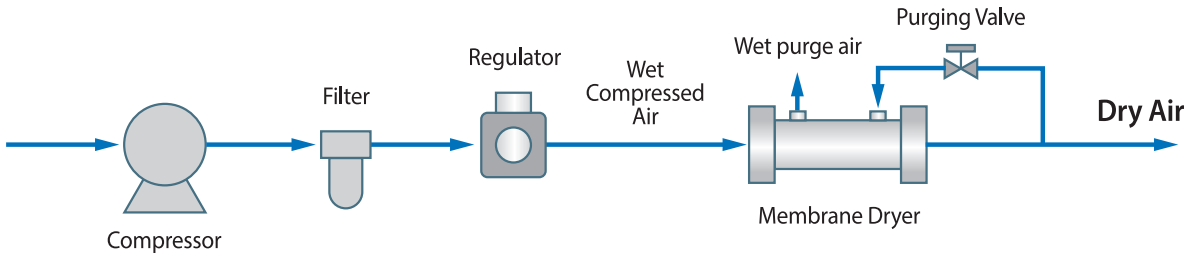
AIRRANE for Dehumidification

Schematic Diagram



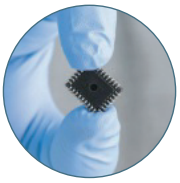
Water is essential to life, but water vapor in air can be damaging to many facilities and processes. From pharmaceutical plants to electronical and chemical manufacturing, food and beverage production and medical equipment, the need for dehumidification is almost universal across all industries. Membrane separation is widely employed as a drying method of choice for its versatility and economic efficiency. Able to cover a broad range of varying conditions and requirements, membrane technology is fit to be your first option for dehumidification.

Key Applications

Low-dewpoint instrument

Drying powder products

Pneumatic Equipment



Dehumidification for
Semi-conductor production

Pressurization for electronic
cabinets

Dehumidified compressed air
for Painting Process

Scientific research equipment &
Analytical process

Medical equipment

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			Weight
	L	OD	ID	Feed	Retentate	Permeate	
MMD-1307A	210	45	40	1/4"	1/4"	1/4"	0.4kg
MMD-1512A	359	55	50	1/2"	1/2"	1/4"	0.9kg
MMD-1522A	589	55	50	1/2"	1/2"	1/4"	1.3kg
MMD-2022A	589	70	60	1/2"	1/2"	3/8"	1.8kg
MMD-3032A	856	110	85	1"	1"	1/2"	6.0kg

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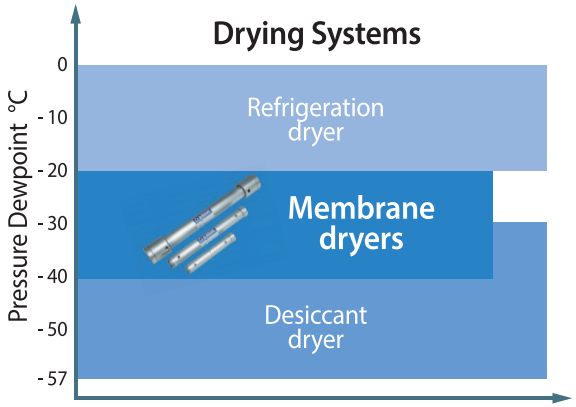
Why Membrane for Dehumidification?

- Easy and versatile installation in all positions
- Immediate operation without any lag time
- Low energy consumption without additional power supply
- Uninterrupted operation cycle
- Eco-friendly process without CFCs/FCs
- Minimal maintenance requirement



Why Membrane for Dehumidification?

Method	Desiccant	Refrigeration	Membrane
Dehumidifying Performance	High	Low	Mid-High
Dew Point	-30 – -57°C	0 – -20°C	-20 – -40°C
Installation Area	Large	Large	Small
Maintenance Requirement	Middle	Middle	Easy
Device Size	Small - Large	Small - Large	Small - Middle
Components	Tower / Tank / Heat Exchanger	Refrigerant / Condenser / Heat Exchanger	Separation Membrane / Filter

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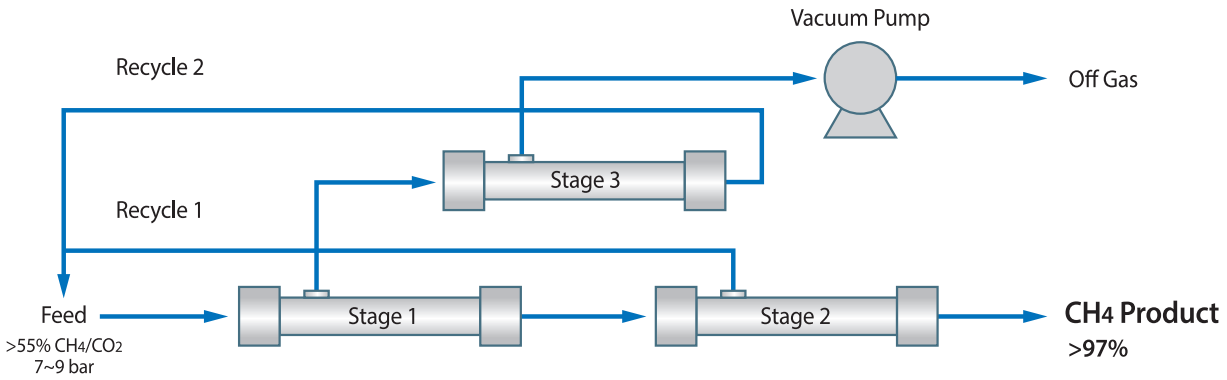
AIRRANE for Biogas Upgrading

Schematic Diagram



*ref : Chem. Eng. Sci, Vol 51, No 3, 1996

Biogas has continued to grow as a next-generation energy source; it is a clean, renewable alternative to natural gas for gas grid, power generation, or even motor fuel. Usually obtained from the anaerobic digestion of organic matters at waste processing plants and landfill sites, biogas requires additional refinement to increase the concentration of methane (CH_4). AIRRANE's membrane separation technology offers a cost-effective solution with high methane recovery rate which makes biogas an efficient and affordable source of renewable energy.

Key Applications

Food Waste Processing Plant

Waste Water Processing Plant

Slurry & Manure Processing at Farms

Landfill Site

Waste Management Facility at Brewery

Crops and Residue from Agricultural Production

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			Weight
	L	OD	ID	Feed	Retentate	Permeate	
MCB-4060A	1580	150	114	1"	1"	1"	17kg
MCB-6060A	1580	200	140	1.5"	1.5"	1.5"	27kg
MCH-6160A	1580	200	158	1.5"	1.5"	1.5"	29Kg

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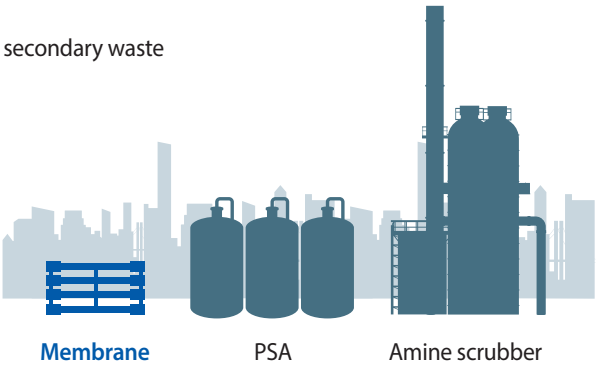
Why Membrane for Biogas?

- Does not require frequent replacement of chemical ingredients that causes secondary waste
- Can operate in wide range of operational pressure
- Less pressure loss for biogas upgrading
- Simple operation and low maintenance requirements
- Flexible operation depending on generated gas amount
- Possible to install for small-scale operation
- Compact size only requires minimal space
- Easy up-scaling



Why Membrane for Biogas?

Method	Scrubber	PSA	Membrane
Energy Requirement	0.32 kWh/Nm^3	0.27kWh/Nm^3	0.30kWh/Nm^3
CH_4 concentration	95% +	95% +	95% +
CH_4 efficiency	95-98%	90-99%	>95%
Moisture Processing	After Separation	Before Separation	Before Separation
Secondary pollution and waste	High	High	Low
H_2S co-removal	Possible	Not possible	Possible
H_2O vapor co-removal	Not possible	Partially possible	Possible
N_2 and O_2 co-removal	Not possible	Partially possible	Partially possible

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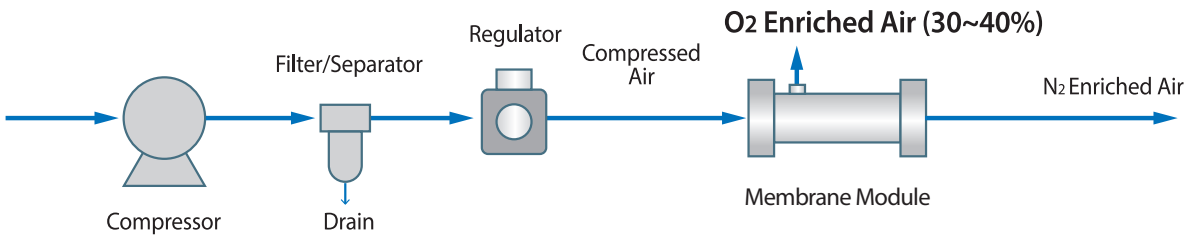
AIRRANE for Oxygen

Schematic Diagram



Just as we can't breathe without oxygen, many industrial and engineering processes require high-concentration oxygen as an essential ingredient. There are, however, also a wide range of applications where lower concentration of oxygen is sufficient without the expensive costs and risk of managing high-concentration oxygen supply. Membrane technology thus presents a cost-effective and safe alternative to high-pressure oxygen cylinders by enabling on-site oxygen generation for a variety of facilities such as clinical uses and air conditioning.

Key Applications

Fuel Efficiency Enhancement
Oxyfuel Combustion

Clinical Oxygen Supply

Portable
Oxygen Generator

Healthcare

Oxygen Chamber

Oxygen Dissolved Water
for Fish Farm

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			Weight
	L	OD	ID	Feed	Retentate	Permeate	
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MNO-2022A	589	70	60	3/8"	3/8"	3/8"	1.8kg
MNO-3032A	856	110	85	1/2"	1/2"	1/2"	6.0kg
MNH-3032A	856	110	85	1/2"	1/2"	1/2"	6.5kg
MNH-4060A	1580	150	114	1"	1"	1"	17kg
MNH-6160A	1580	200	158	1.5"	1.5"	1.5"	29kg

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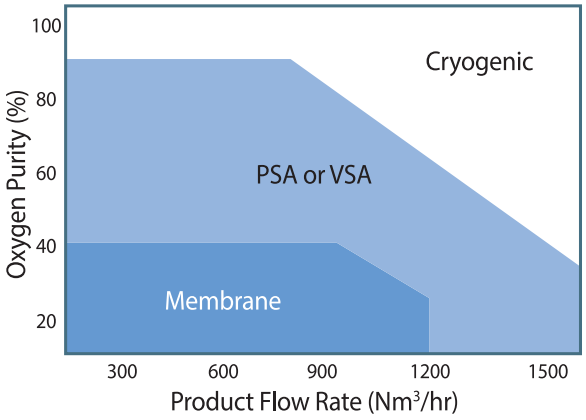
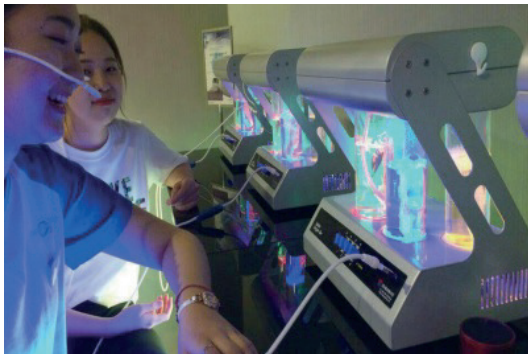
Why Membrane for Oxygen?

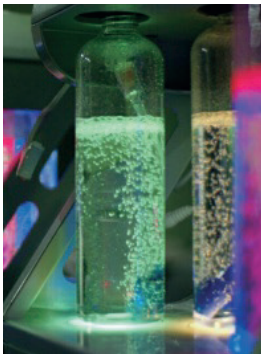
- Easy installation with low set-up costs
- Quick start-up: oxygen-enriched air is immediately provided upon start-up of the separator without any delay
- Flexible application makes it an effective solution for a wide range of facilities from small oxygen generators to large boiler system
- Easy operation and Minimal maintenance requirements
- Portable equipment for oxygen generation



Why Membrane for Oxygen?

Method	Cryogenic	PSA	Membrane
Oxygen Concentration	Over 99.9%	80 - 90%	30 - 40%
Installation Costs	High	High	Low
Installation Area	Large	Large	Small
Structural Features	High pressure process Need Evaporator	Batch Type Swing Process Absorbent powder residue	Simple Structure Bacteria-Free, Dust-Free
Device Size	Large	Small - Large	Small - Middle
Components	Tower / Tank /High pressure Compressor/ Refrigerator	Tower/Tank/Filter Absorbent/Swing valve/ Silencer	Separation Membrane / Filter





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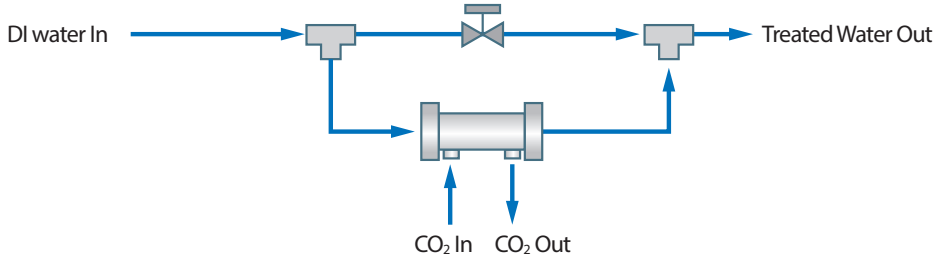
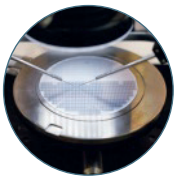
AIRRANE for CO_2 Injection & Bubbler

Schematic Diagram



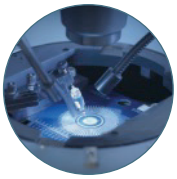
Semi-conductor and Display industry require significant amount of deionized water for cleaning process. Dissolved CO_2 in the deionized water reduces electric conductivity of the surface of wafers and display glasses, which is necessary to reduce the defect rate of the production line. Airrane provides both CO_2 injection membrane module and CO_2 bubbler device as well.

Key Applications



Ultrapure water for semi-conductor wafer cleaning process

Ultrapure water for display glass cleaning process



Applications for anti-static treated water required

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			DI Water
	L	D	D	Feed	Retentate	CO_2 In / Out	
MDB-1004P	50	141	104	1/4"	1/4"	1/4"	0.2~2.0L/m
MDB-1607P	60	218	180	1/2"	1/2"	1/8"	2.0~15L/m
MDB-2108P	76	274	200	1"	1"	1/4"	15~30L/m
MDB-2510P	79	350	250	1.5"	1.5"	1/4"	10~50L/m

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Why Airrane for CO_2 bubbler?

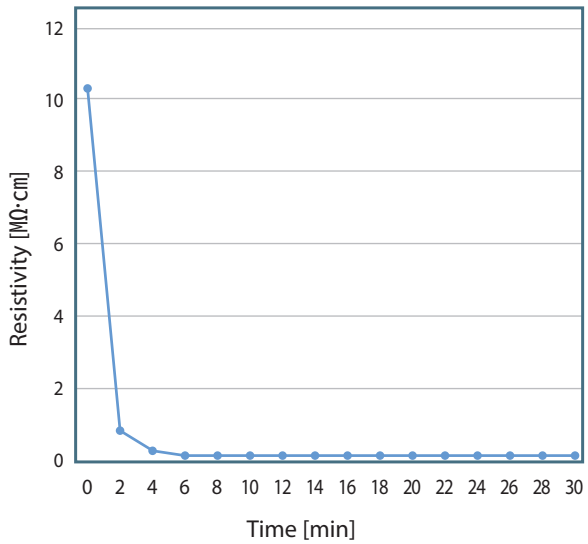
- Airrane is a patent-protected membrane manufacturer
- Fast CO_2 dissolution time
- Simple design reduces maintenance requirements
- Real time data transfer system provides user's convenience

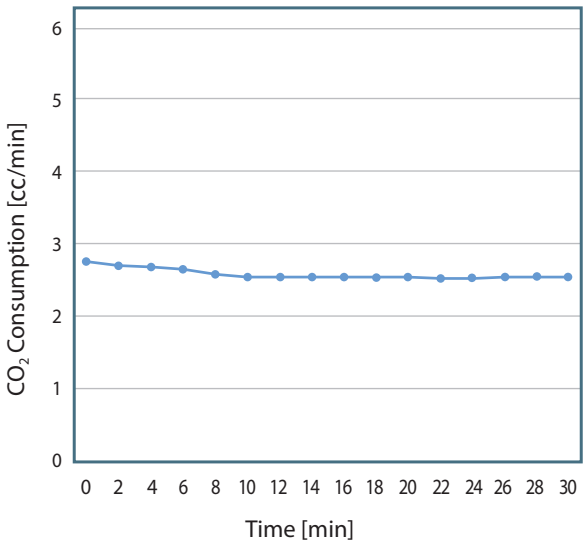
CO_2 Injection Membrane / CO_2 Bubbler

CO_2 Injection Membrane

CO_2 Bubbler

Performance Diagram





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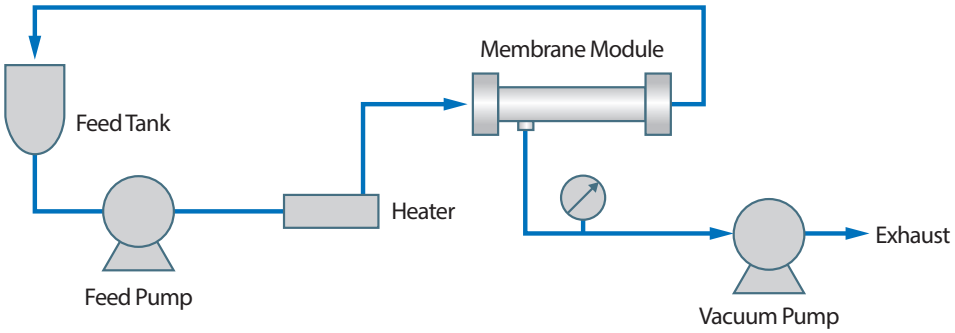
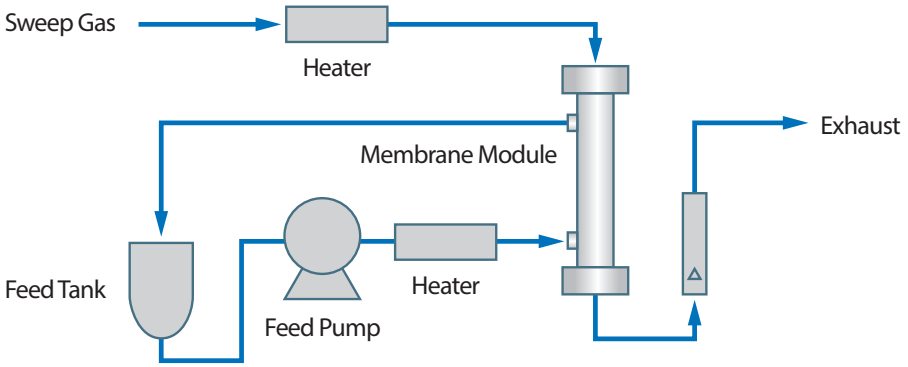
Airrane for Pervaporation & Vapor Permeation

Schematic Diagram

Vacuum method



Sweeping method



Pervaporation is derived from the two steps of the process, permeation through the non-porous membrane by the permeate, then its evaporation into the vapor phase which is condensed into liquid phase. Membrane acts as a selective barrier between the two phases, the liquid-phase feed and the vapor-phase permeate. It allows the desired component of the liquid feed to transfer through it by vaporization. Pervaporation technology could be applied to the separation of alcohol/water mixture, organic compound/water mixture and vapor permeation process.

Key Applications

Pervaporation

- Dehydration of water/organic liquid mixture
- Removal of VOCs from water/organic liquid mixture
- Separation of organic/organic liquid mixture

Vapor permeation

- Monomer recovery from polymerization process
- Oil mist collect from oil storage tank

AIRRANE Product Specifications

Model Number	Dimension (mm)			Connection (inch)			Weight
	L	OD	ID	Feed	Retentate	Permeate	
MVB-6040P	1080	200	150	1.5"	1.5"	1.0"	19kg

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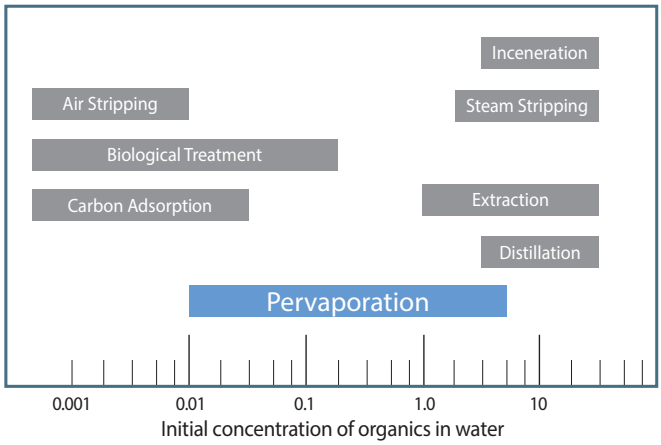
Why Membrane Pervaporation?

- Low cost separation without chemical additives
- Effective separation even with small gap of boiling points of mixture.
- Low energy consumption system for vapor permeation
- Compact size facility with module designing
- Easy and quick start-up system
- High purity permeate attainable



Comparison of the separation methods for VOCs removal from water

Comparison of dehydration costs of ethanol from 94 vol% to 99.9 vol% by different techniques

Utilities	Vapor-permeation (€/t)	Pervaporation (€/t)	Entrainer distillation (€/t)	Molecular Sieves Adsorption (€/t)
Vapor	-	6.40	60.00	40.00
Electricity	20.00	8.80	4.00	2.60
Cooling water	2.00	2.00	7.50	5.00
Replacement of membranes	9.50	15.30	-	-
Entrainer	-	-	4.80	-
Replacement of molecular sieves	-	-	-	25.00
Total costs	31.50	32.50	76.30	72.60

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