23

MODULI DUPONT PER DEGASAZIONE

DEGASIFICATION DUPONT MODULES

hytek | Hydrotecnologies

Moduli Ligasep™ Dupont™ per Degasazione / Dupont™ Ligasep™ Degasification Modules

Riepilogo della tecnologia

Come i gas entrano in acqua
L'aria è costituita principalmente da azoto (N_2) e ossigeno (O_2) - a pressione atmosferica, 79% N_2 e 21% O_2. Ogni volta che l'aria viene a contatto con l'acqua, questi gas si dissolvono naturalmente nell'acqua. Un bicchiere d'acqua conterrà circa 8,5 ppm di ossigeno e 14 ppm di azoto perché è a contatto con l'aria atmosferica. L'anidride carbonica (CO_2) si dissolverà nell'acqua mentre l'acqua fluisce sulla terra. L'acqua dissolverà i minerali comuni come carbonato di calcio e carbonato di magnesio.Quando i minerali si dissolvono formano ioni di calcio e magnesio, nonché anidride carbonica e acido carbonico (H_2CO_3 - le specie ionizzabili in equilibrio con l'anidride carbonica gassosa quando la CO_2 viene sciolta in acqua):

$$CaCO_3 + 2H+ \rightarrow Ca_2+ + CO_2 + H_2O$$
$$CO_2(g) + H_2O \leftrightarrow CO_2(aq) + H_2O$$
$$CO_2(aq) + H_2O \leftrightarrow H_2CO_3$$

La quantità di anidride carbonica disciolta nell'acqua dipenderà dalla quantità di carbonato di calcio e di magnesio che la fonte d'acqua ha disciolto; alcune regioni hanno quantità molto più elevate di questi minerali rispetto ad altre. L'acqua con grandi quantità di minerali viene comunemente definita acqua dura.

Perché i gas vengono rimossi

Ossigeno
L'ossigeno viene rimosso dall'acqua perché reagisce con i metalli e ossiderà qualsiasi metallo a contatto. Due importanti settori interessati dall'ossigeno che reagisce con i metalli sono l'industria della produzione di energia e quella dei semiconduttori.
Le centrali elettriche a vapore generano vapore per creare una forza che spinge una serie di pale montate su un albero (simile a un'elica). Mentre l'albero ruota, converte l'energia meccanica in energia elettrica. Queste lame sono in metallo e sono soggette a ossidazione. Se i metalli nelle pale della turbina iniziano a ossidarsi, si danneggiano e influiscono sulle prestazioni della turbina.
Gli impianti di produzione di semiconduttori, utilizzano un grande volume di acqua per sciacquare il wafer di silicio mentre attraversano diverse fasi di lavorazione. Il wafer può passare attraverso 40-50 singole fasi di lavorazione e ciascuna fase sarà seguita da un risciacquo per rimuovere le sostanze chimiche utilizzate nel processo. L'ossigeno nell'acqua reagirà e ossiderà i metalli utilizzati nel circuito integrato. Gli ossidi avranno un impatto sui circuiti e creeranno difetti.
Target ossigeno disciolto:
- <1 ppb (parte per miliardo) per circuiti integrati
- <50 ppb per display TFT
- <10 ppb per centrali elettriche

Anidride carbonica
La purezza dell'acqua è spesso misurata dalla sua capacità di condurre l'elettricità. Gli ioni nell'acqua consentiranno di condurre l' elettricità. L'acqua ultrapura avrà una conduttività molto bassa poichè ha pochissimi ioni disciolti. L'anidride carbonica sarà in equilibrio con l'acido carbonico, che ionizzerà e aumenterà la conduttività dell'acqua.
La resina a scambio ionico rimuove gli ioni e può essere utilizzata per rimuovere anche l'anidride carbonica. Con l' aumento dei livelli di anidride carbonica, diventerà più economico rimuoverla usando un metodo meccanico anziché a scambio ionico. È uso comune installare un decarbonatatore (aka, degaser) per rimuovere l'anidride carbonica disciolta.
- Obiettivo CO_2 <3 ppm

Come rimuovere i gas dall'acqua
Per comprendere la meccanica alla base della rimozione del gas è importante rivedere due principi di ingegneria chimica. Questi principi sono semplificati di seguito.

Legge di Henry
I gas si dissolvono nell' acqua ogni volta che ne vengono in contatto. La quantità di gas che si discioglie è proporzionale alla pressione del gas. Questo è governato da un principio di ingegneria chimica chiamato legge di Henry.

Legge di Henry: $P = Hx$

Technology Summary

How Gases Get into Water
Air is made up mostly of nitrogen (N_2) and oxygen (O_2) – at atmospheric pressure, 79% N_2 and 21% O_2. Whenever air is in contact with water, these gases naturally dissolve into the water. A glass of water will contain around 8.5 ppm of oxygen and 14 ppm of nitrogen because it is in contact with the atmospheric air. Carbon dioxide (CO_2) will dissolve in water as the water flows over the earth. Water will dissolve common minerals such as calcium carbonate and magnesium carbonate.When the minerals dissolve they form calcium and magnesium ions as well as carbon dioxide and carbonic acid (H_2CO_3—the ionizable species in equilibrium with gaseous carbon dioxide when CO_2 is dissolved in water):

$$CaCO_3 + 2H+ \rightarrow Ca_2+ + CO_2 + H_2O$$
$$CO_2(g) + H_2O \leftrightarrow CO_2(aq) + H_2O$$
$$CO_2(aq) + H_2O \leftrightarrow H_2CO_3$$

The amount of carbon dioxide dissolved into the water will depend on how much calcium carbonate and magnesium carbonate the water source has contacted; some regions have much higher amounts of these minerals than others. Water with large amounts of minerals is commonly referred to as hard water.

Why Gases are Removed

Oxygen
Oxygen is removed from water because it reacts with metals and will oxidize any metal it contacts. Two major industries concerned with oxygen reacting with metals are the Power Generation industry and the Semiconductor Manufacturing industry.
Steam power plants generate steam to create a force to push a series of blades mounted on a shaft (similar to a propeller). As the shaft rotates it converts the mechanical energy to electrical energy. These blades are made of metal and are prone to oxidation. If the metals in the turbine blades start oxidizing they will become damaged and impact the performance of the turbine.
Semiconductor manufacturing plants use a large volume of water to rinse the silicon wafer as they go through different processing steps. The wafer may go through 40 – 50 individual processing steps and each step will be followed by a rinse to remove chemicals used in the process.
Oxygen in the water will react and oxidize metals used in the integrated circuit. The oxides will impact the circuits and create defects.
Target dissolved oxygen:
- < 1 ppb (part per billion) for integrated circuits
- < 50 ppb for TFT displays
- < 10 ppb for power plants

Carbon Dioxide
Water purity is often measured by its ability to conduct electricity. Ions in the water will allow the water to conduct electricity. Ultrapure water will have a very low conductivity indicating it has very few or virtually no ions in the water. Carbon dioxide will exist in equilibrium with carbonic acid, which will ionize and increase the conductivity of water.
Ion exchange resin will remove ions and can be used to remove carbon dioxide. As the level of carbon dioxide increases it becomes more economical to remove the carbon dioxide using a mechanical method rather than ion exchange. It is common to install a decarbonator (aka, degaser) to remove dissolved carbon dioxide from water.
- Target CO2 < 3 ppm

How to Remove Gases from Water
In order to understand the mechanics behind gas removal it is important to review two chemical engineering principles. These principles are simplified below.

Henry's Law
Gases will dissolve in water whenever they are in contact with the water. The amount of gas that will dissolve in water is proportional to the pressure of the gas. This is governed by a chemical engineering principal called Henry's Law.

Henry's Law: $P = Hx$

P = pressione parziale del gas
H = costante
x = quantità di gas disciolto nell'acqua

Legge di pressione parziale di Dalton

In una miscela di gas ogni gas esercita la propria pressione o pressione parziale. La pressione totale del gas è la somma di tutte le pressioni parziali nella miscela di gas. La pressione parziale di un gas è la pressione totale moltiplicata per la frazione % del gas presente nella miscela.

Legge di Dalton: Pt = P1 + P2 + P3 +....

Pt = pressione totale della miscela di gas
P1 = pressione parziale del gas 1
P2 = pressione parziale del gas 2

Esempio:

L'aria è composta per il 21% di ossigeno e per il 79% di azoto. Ad un' atmosfera, l'ossigeno esercita una pressione parziale di 0,21 atmosfere mentre l' azoto di 0,79 atmosfere. L'ossigeno e l'azoto si dissolveranno nell' acqua proporzionalmente alle loro pressioni parziali. Se sostituiamo l'aria a contatto con l'acqua con azoto, la pressione parziale dell'azoto aumenterà a 1,0 atmosfera e la pressione parziale dell'ossigeno diminuirà fino 0 atmosfere. L'azoto aggiuntivo si dissolverà nell'acqua e successivamente l'ossigeno si sposterà fuori da questa.

P = gas partial pressure
H = constant
x = amount of gas dissolved into the water

Dalton's Law of Partial Pressure

In a gas mixture each gas exerts its own pressure or partial pressure. The total gas pressure is the sum of all of the partial pressures in the gas mixture. The partial pressure of a gas is the total pressure times the % fraction of the gas in the gas mixture.

Dalton's Law: Pt = P1 + P2 + P3 + ...

Pt = total pressure of the gas mixture
P1 = partial pressure of gas component 1
P2 = partial pressure of gas component 2

Example:

Air is made up of 21% oxygen and 79% nitrogen. At one atmosphere oxygen exerts a partial pressure of 0.21 atmospheres and nitrogen 0.79 atmospheres. Oxygen and nitrogen will dissolve in water proportional to these partial pressures. If we replace the air in contact with the water with nitrogen, the partial pressure of the nitrogen will increase to 1.0 atmospheres and the oxygen partial pressure will decrease to 0 atmospheres. Additional nitrogen will dissolve into the water and oxygen will subsequently move out of the water.

Ligasep™ LDM-040
Ligasep™ LDM-120
Degasification Modules

HS: for High Solubility gases
LS: for Low solubility gases

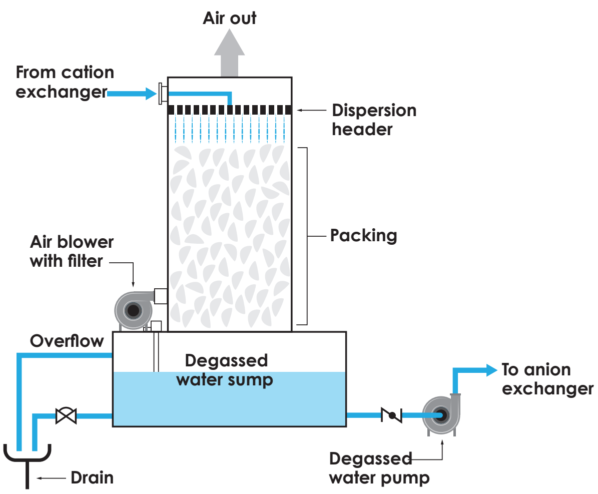
Model	Target gas	Flow Rate (m^3/h)	Dimensions (mm)	Pressure Rating (bar)	Temperature Range
LDM-040-LS	O_2	0,5 to 11	180 x 673	7 bar (<40°C) 5 bar (<50°C)	2 – 50 °C
LDM-120-LS	O_2	5 to 50	315 x 850		
LDM-040-HS	CO_2	0,5 to 11	180 x 673		
LDM-120-HS	CO_2	5 to 50	315 x 850		

Le tecniche di rimozione useranno questo concetto per ridurre la pressione parziale del gas a contatto con l'acqua al fine di rimuoverlo da questa.

La tecnologia di degasazione convenzionale, spruzza l'acqua in goccioline all' interno di una torre; la creazione di goccioline aumenta l'area di contatto del liquido gassoso migliorandone l' efficienza. La torre è progettata per funzionare sotto vuoto (per ridurre la pressione totale della miscela di gas) o con un gas pulente (per sostituire il gas a contatto con l'acqua con un altro gas). Quando si rimuove l'anidride carbonica, l'aria viene spesso utilizzata per mantenere un gas esente da CO_2 a contatto con l'acqua. Nel caso dell'anidride carbonica, la solubilità del gas è molto alta, quindi l'aria deve essere continuamente sostituita per assicurare che non vi sia anidride carbonica nel gas a contatto con l'acqua.

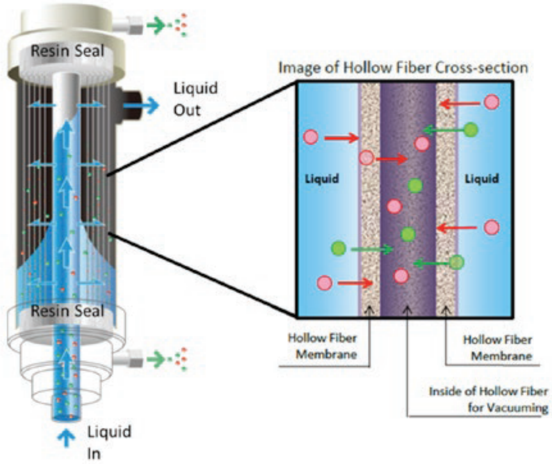
Gas removal techniques will use this concept to lower the partial pressure of the gas in contact with the water to remove the gas from the water.

Conventional degasification technology sprays the water into droplets in a tower; creating droplets increases the gas liquid contact area and improves the efficiency. The tower is designed to operate under a vacuum (to lower the total pressure of the gas mixture) or with a sweep gas (to replace the gas in contact with water with another gas). When removing carbon dioxide, air is often used to maintain a CO_2 free gas in contact with the water. In the case of carbon dioxide, the gas solubility is very high so the air must be continuously replaced to assure that no carbon dioxide is in the gas that is in contact with the water.



La tecnologia di degasazione della membrana, porta le fasi gassose e liquide a contatto tra loro attraverso una membrana idrofobica. La membrana non consente all'acqua di passare attraverso la membrana ma consente liberamente il passaggio del gas. Questo crea una vasta area di contatto (10 volte quella di una torre) che massimizza l'efficienza. Proprio come in una torre, le concentrazioni di gas e la pressione su un lato della membrana, vengono regolate per rimuovere i gas dall'acqua.

Membrane degasification technology brings the gas and liquid phases in contact with each other across a hydrophobic membrane. The membrane does not allow water to pass through the membrane but freely allows gas to pass through. This creates a large contact area (10X that of a tower) that maximizes the efficiency. Just as in a tower, the gas concentrations and pressure on one side of the membrane are adjusted to remove gases from the water.



Dupont™ Ligasep™ Degasification Modules Models LDM-040-HS, LDM-040-LS

Description

Ligasep™ Degasification Modules use a proprietary Polymethylpentene (PMP) hollow fiber membrane that provides an efficient transfer of gases between a liquid and a gas. These modules are ideal for deoxygenation, decarbonation, and gas control of liquids.

Ligasep™ Degasification Modules have the following features:

- Utilizes a hollow fiber membrane with a skin layer that reduces the passage of water vapor through the membrane. Low water vapor passage across the membrane allows blowers and other vacuum pump technologies to be used on the gas side of the membrane.
- The membrane offers a barrier that prevents mixing between the gas and the liquid, hence avoiding any cross-contamination between both fluids.
- Provides a stable and efficient contact area, allowing the modules to achieve low dissolved gas levels at outlet.
- Immediate transfer of gas allows for a rapid start-up.
- Low pressure drop across the module eliminates the need for a booster pump, reducing energy consumption.
- Inline installation ensures continuous operation and improving process reliability.

“LS” fiber is typically used in applications with gases with lower solubility in water, such as oxygen, and where high levels of removal are required.

“HS” fiber is designed for more efficient contact between the sweep gas and the liquid, which is ideal for gases that have a high solubility in water, such as CO_2, H_2S, and NH_3.

Applications

- Boiler feedwater
- Ultrapure water
- Deionized water

Industries

- Industrial water treatment
- Power
- Beverage
- Oil & Gas
- Microelectronics
- Pharmaceutical

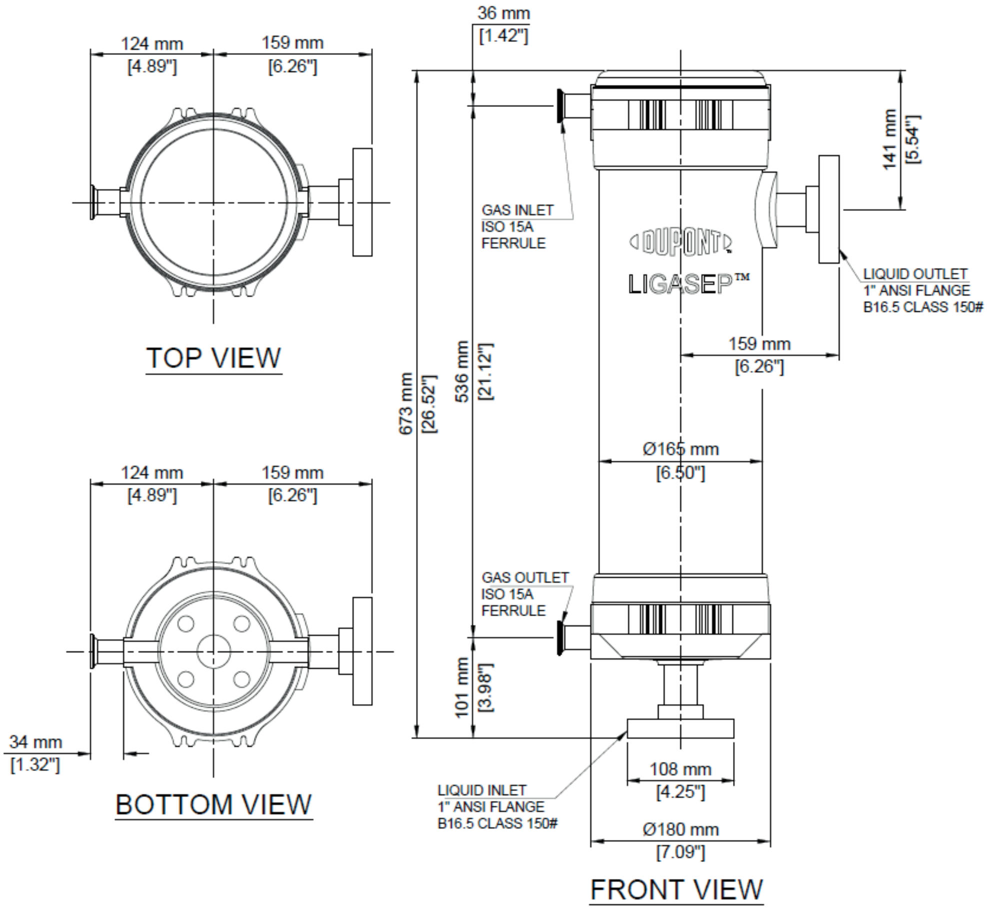
Product Properties

Configuration	
Flow Structure	External Flow
Connection Type	
Liquid	1” ANSI B16.5 class 150
Gas	ISO 15A Ferrule
Physical Properties	
Volume (liquid phase)	6.5 L (1.7 gal)
Height (including flanges)	673 mm (26.5 in)
Diameter	180 mm (7.1 in)
Weight	
Empty	10 kg (22.1 lb)
Full	16.5 kg (36.4 lb)
Materials of Construction	
Hollow Fiber Membrane	Polymethylpentene (PMP)
Housing	PVC
Cap	Polysulfone
Pipe	Polysulfone
Sealing Resin	Epoxy resin, Polyurethane resin
O-ring	EPDM

Suggested Operating Conditions

Water Flowrate	3 – 6 m^3/h (13.2 – 26.4 gpm)
Temperature Range	2 – 50°C (35.6 – 122°F)
Water Pressure	
2 – 40°C (35.6 – 104°F)	≤ 7 bar (101.5 psig)
40 – 50°C (104 – 122°F)	≤ 5 bar (72.5 psig)
Operating Vacuum Level	10 – 760 mmHg (Torr)
Feedwater Characteristics	
Total Suspended Solids	< 1 ppm
Total Dissolved Solids	Under saturation limits
Total Organic Carbon	< 1 ppm
Oil & Grease	< 0.1 ppm
Free Chlorine	< 0.1 ppm
Oxidizer	Not detectable
pH Range	1 – 13
Turbidity	< 0.5 NTU
SDI_{15}	< 3

Dimensions



Product Stewardship

DuPont has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with DuPont products—from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

DuPont strongly encourages its customers to review both their manufacturing processes and their applications of DuPont products from the standpoint of human health and environmental quality to ensure that DuPont products are not used in ways for which they are not intended or tested. DuPont personnel are available to answer your questions and to provide reasonable technical support. DuPont product literature, including safety data sheets, should be consulted prior to use of DuPont products. Current safety data sheets are available from DuPont.

Dupont™ Ligasep™ Degasification Modules Models LDM-120-HS, LDM-120-LS

Description

Ligasep™ Degasification Modules use a proprietary Polymethylpentene (PMP) hollow fiber membrane that provides an efficient transfer of gases between a liquid and a gas. These modules are ideal for deoxygenation, decarbonation, and gas control of liquids.

Ligasep™ Degasification Modules have the following features:

- Utilizes a hollow fiber membrane with a skin layer that reduces the passage of water vapor through the membrane. Low water vapor passage across the membrane allows blowers and other vacuum pump technologies to be used on the gas side of the membrane.
- The membrane offers a barrier that prevents mixing between the gas and the liquid, hence avoiding any cross-contamination between both fluids.
- Provides a stable and efficient contact area, allowing the modules to achieve low dissolved gas levels at outlet.
- Immediate transfer of gas allows for a rapid start-up.
- Low pressure drop across the module eliminates the need for a booster pump, reducing energy consumption.
- Inline installation ensures continuous operation and improving process reliability.

"LS" fiber is typically used in applications with gases with lower solubility in water, such as oxygen, and where high levels of removal are required.

"HS" fiber is designed for more efficient contact between the sweep gas and the liquid, which is ideal for gases that have a high solubility in water, such as CO_2, H_2S, and NH_3.

Applications

- Boiler feedwater
- Ultrapure water
- Deionized water

Industries

- Industrial water treatment
- Power
- Beverage
- Oil & Gas
- Microelectronics
- Pharmaceutical

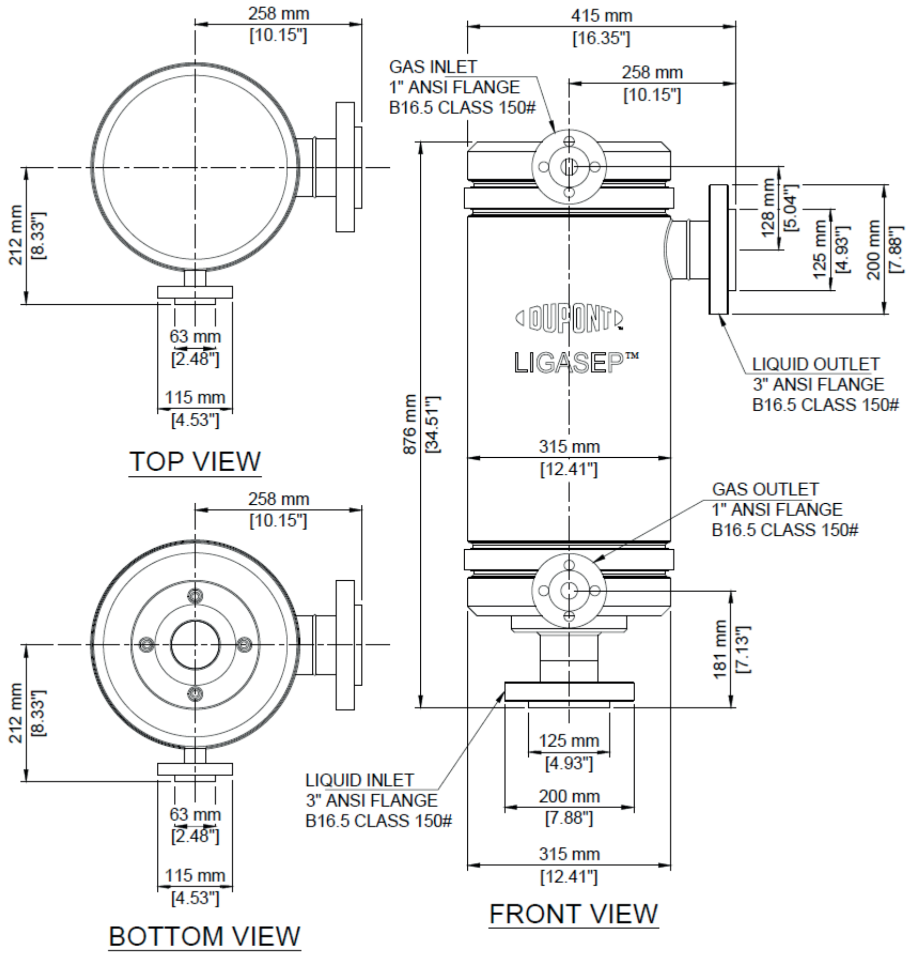
Product Properties

Configuration	
Flow Structure	External Flow
Connection Type	
Liquid	3” ANSI B16.5 class 150
Gas	1” ANSI B16.5 class 150
Physical Properties	
Volume (liquid phase)	18 L (4.8 gal)
Height (including flanges)	876 mm (34.5 in)
Diameter	315 mm (12.4 in)
Weight	
Empty	35 kg (77.2 lb)
Full	52 kg (114.7 lb)
Materials of Construction	
Hollow Fiber Membrane	Polymethylpentene (PMP)
Housing	Polypropylene
Cap	Polypropylene
Pipe	Polypropylene
Sealing Resin	Epoxy resin, Polyurethane resin
O-ring	EPDM

Suggested Operating Conditions

Water Flowrate	5 – 50 m^3/h (22 – 220 gpm)
Temperature Range	2 – 50°C (35.6 – 122°F)
Water Pressure	
2 – 40°C (35.6 – 104°F)	≤ 7 bar (101.5 psig)
40 – 50°C (104 – 122°F)	≤ 5 bar (72.5 psig)
Operating Vacuum Level	10 – 760 mmHg (Torr)
Feedwater Characteristics	
Total Suspended Solids	< 1 ppm
Total Dissolved Solids	Under saturation limits
Total Organic Carbon	< 1 ppm
Oil & Grease	< 0.1 ppm
Free Chlorine	< 0.1 ppm
Oxidizer	Not detectable
pH Range	1 – 13
Turbidity	< 0.5 NTU
SDI_{15}	< 3

Dimensions



Product Stewardship

DuPont has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with DuPont products—from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

DuPont strongly encourages its customers to review both their manufacturing processes and their applications of DuPont products from the standpoint of human health and environmental quality to ensure that DuPont products are not used in ways for which they are not intended or tested. DuPont personnel are available to answer your questions and to provide reasonable technical support. DuPont product literature, including safety data sheets, should be consulted prior to use of DuPont products. Current safety data sheets are available from DuPont.