Liqui-Cel™ Membrane Contactors

3M™ Liqui-Cel™ Membrane Contactor Technology Being Evaluated for Dissolved Gas Removal from Water in Many Hydrocarbon Processes

The oil and gas industry has utilized various deaeration technologies for many years to remove dissolved gases, particularly oxygen, from injection water. In many hydrocarbon recovery and water processes, degassing is necessary in order to minimize environmental impact, improve operating efficiency, avoid process issues and help protect system components.

Common methods of deoxygenation include installing a vacuum tower and/or chemical injection. (For example, dosing water with sodium bisulfite). However, vacuum towers are bulky and use an enormous footprint. They cannot be easily expanded to meet future demand and, in many cases, are not operated at optimal efficiency because planned flow capacity may change after tower construction begins or even after installation. Additionally, vacuum towers can also have long lead times, so ordering must be done well in advance.

Removing dissolved gases with chemicals requires storing large volumes of chemicals and handling by employees. Environmental regulations are becoming more stringent, which increases chemical disposal costs.

Now, however, there is increasing discussion and activity around using membrane contactor technology to remove dissolved gases from water in many hydrocarbon related applications. High-pressure 3M™ Liqui-Cel™ EXF-8×40 and EXF-8×80 Series Membrane Contactors use a much smaller footprint and weigh far less than deaeration towers – and they do not require chemicals to operate.

Figure 2. 3M™ Liqui-Cel™ EXF-8×80 Series Membrane Contactor System

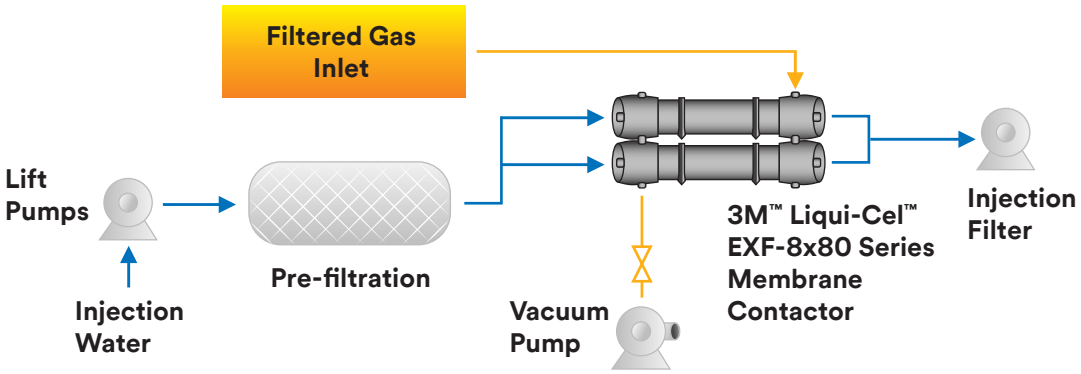
In addition, Liqui-Cel contactors maintain positive pressure after degassing, eliminating the need for booster pumps or reducing booster pump capacity requirements. Liqui-Cel contactors are ASME code-rated to 300 psi to handle high inlet pressures.

Figure 1. Estimated comparison of 3M™ Liqui-Cel™ Membrane Contactor technology vs. traditional deaeration towers
Lower concentrations of dissolved gases can be achieved with less weight and a smaller footprint.

	250,000 BWPD		115,000 BWPD	
Properties	**3M™ Liqui-Cel™ EXF-8×80**	**Vacuum Tower**	**3M™ Liqui-Cel™ EXF-8×80**	**Vacuum Tower**
Height (ft.)	11-20	60-75	11-20	57-72
Footprint (sqft.)	310	530	172	255
Dry Weight (lbs.)	13,800	62,000	6,900	32,000
Operating Weight (lbs.)	21,840	125,000	10,920	61,000
Flooded Weight (lbs.)	21,840	310,000	10,920	145,000
Average O_2 Outlet	<10ppb	<10ppb	<10ppb	<10ppb

Footprint dimensions and weights are estimates only and will vary according to project requirements.

Figure 3. Sample P&ID for seawater injection degassing system



3M™ Liqui-Cel™ Membrane Contactor Technology

3M™ Liqui-Cel™ Membrane Contactors use a microporous hollow fiber membrane to remove gases from or add gases to liquids. Gas flows on one side of the membrane and liquid flows on the other side at a higher pressure relative to the gas stream. Because the membrane is hydrophobic, it prevents intrusion of liquid into the pores and acts as an inert support that allows direct contact between a gas and a liquid phase without dispersion.

Applying a vacuum and/or an inert sweep gas to the gas phase lowers the partial pressure of the target gas. This creates the driving force for dissolved oxygen in the liquid to transfer through the hollow fiber membrane pores. The transferred oxygen is then carried away by the vacuum pump or sweep gas.

Water Degasification Opportunities

Water Flooding/Injection Water

Oil can initially be retrieved from a reservoir only using the natural lift mechanisms, such as gravity, natural water displacement, gas expansion and others. However, over time these natural mechanisms will no longer provide sufficient pressure to force oil to the the reservoir to keep up the production rate. One such method that is commonly used is water injection.

Water injection entails sending large volumes of water into a well to keep pressure elevated enough to lift oil to the surface. Injection water can come from several sources including seawater, river water, produced water and even aquifer water.

After pre-filtration, injection water is deoxygenated to reduce the impact of corrosion and to help prevent the growth of bacteria that can produce toxic hydrogen sulfide. Bacterial growth can also lead to serious production problems and impede extraction by blocking the pores in the rock.

Historically, to remove dissolved O_2 from injection water, bulky deaeration towers and oxygen scavenging agents were used. Currently, Liqui-Cel membrane contactor technology is being evaluated in various hydrocarbon extraction applications to displace these older technologies because of the reduced weight and footprint used by the contactors. Liqui-Cel membrane contactors also maintain positive pressure after degassing, which can eliminate the need for booster pumps. They are modular and can be easily expanded to meet capacity demands even after initial installation.

Case Study 1: 3M™ Liqui-Cel™ Membrane Contactor Deoxygenating Injection Seawater

Currently, a Liqui-Cel membrane contactor system is being used in a pilot trial at a major oil and gas producer in the United States. The membrane contactors have been shown to remove dissolved oxygen from filtered seawater for injection purposes. The system skid is intended to be placed on an offshore platform in the next pilot phase.

Corrosion Control in Boiler Feedwater

Steam flooding, cyclic steam injection and steam-assisted gravity drainage are all methods that are being used more widely to extract heavy oil. Steam injection is the main thermally enhanced oil recovery (TEOR) method of stimulation used in tertiary recovery applications.

In this process, boilers are used to provide the constant flood of steam required for injection; however, dissolved gases in the feedwater must be removed to help control corrosion within the boiler and piping. Liqui-Cel membrane contactors remove dissolved gases with minimal or no chemical usage. Boiler feedwater degassing is a common application for these membrane contactors.

Case Study 2: 3M™ Liqui-Cel™ Membrane Contactors Used for Degassing Boiler Feedwater

Liqui-Cel membrane contactor degassing systems are in operation on multiple derricks in Venezuela to remove oxygen from boiler feedwater. These installations are being used to help prevent corrosion and pitting within the boiler to protect capital investment.

Degassing Produced Water

During oil and gas extraction, formation water is brought to the surface along with the gas or oil. The water that comes to the surface is known as produced water and can contain a mixture of oil, gas, inorganic salts, organic compounds, bacteria, injected chemicals, dissolved gases and solid particles. The concentrations of each component can vary widely depending on the well location. Water quality can range from meeting federal or state drinking water standards to low quality levels with Total Dissolved Solids (TDS) up to 180,000ppm.

Produced water may be contaminated with chemicals added during water injection or with naturally occurring heavy metal components. Iron compounds and sulfur deposits may also form when the water is exposed to oxygen in the air. Therefore, water treatment must take place before produced water can be disposed of in accordance with environmental regulations.

There are several methods available to dispose of the produced water. According to the Produced Water Society, 65% of the produced water generated in the United States is injected back into the producing formation, 30% into deep saline formations and 5% is discharged to surface waters. Produced water that is re-injected goes through several water treatment process steps for purification which often includes deoxygenation.

Case Study 3: 3M™ Liqui-Cel™ Contactors Degas Produced Water in Coal Seam Gas (CSG) Extraction

Produced water treatment systems using Liqui-Cel membrane contactors for this application are currently being evaluated in Australia. The company extracting the gas faced environmental considerations when evaluating how to dispose of the produced water that was to be re-injected into underground aquifers.

To meet the water quality standards for re-injection, a water treatment system was built that would include filtration, RO, UV and Liqui-Cel membrane contactors, which are used to deoxygenate the produced water before re-injection. Dissolved O_2 concentration levels at the water treatment system outlet should be lower than the dissolved oxygen concentration levels of the formation water.

Figure 3. 3M™ Liqui-Cel™ EXF-14×40 Series Membrane Contactor in CSG Pilot Degassing System

Liqui-Cel membrane contactors are expected to achieve low oxygen concentration levels in water for re-injection while minimizing chemical usage.

To learn more about Liqui-Cel technology or to obtain a detailed system sizing, please contact your 3M representative or visit 3M.com/Liqui-Cel.

Certified System ™
ISO 9001

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