3M | Liqui-Cel™ Membrane Contactors

Chemical Cost Comparison of a Conventional Deaerator vs. a 3M™ Liqui-Cel™ Membrane Contactor System

Mixed bed ion exchange polishes Reverse Osmosis (RO) permeate in many industrial water systems. This process has been utilized for several years and it is well known to manage dissolved carbon dioxide (CO_2), which typically accounts for the largest anion load in a DI system.

Removing CO_2 for efficient RO is normally managed using one of the following methods:

1. Conventional degassifying with a Forced Draft Tower
2. 3M™ Liqui-Cel™ Membrane Contactors

This technical brief compares the performance and operating costs of Liqui-Cel membrane contactors with conventional forced draft tower technology for CO_2 removal. This brief will also show why membrane degassing is the economical and value added technology of choice for oxygen and carbon dioxide removal from water.

This comparison is based on an actual water system currently operating at a plant in China. The system consists of three 110 m³/hr lines, with each line consisting of an RO+Mixed Bed system. Due to high chemical (HCL and NaOH) regeneration costs, the plant considered deaerating the water prior to using the Mixed Bed. The plant evaluated two system designs:

1. RO + Forced Draft Tower + Mixed Bed
2. RO + Liqui-Cel + Mixed Bed.

Table 1: Mixed Bed Regeneration Chemical Consumption Per Cycle

System Configuration	Outlet CO_2	MB Size	MB Gross Product Water	Net Volume	Chemical Consumption per Cycle		Neutralization HCL Consumption
					30% HCL (Kg)	100% NaOH	30% HCL
Without CO_2 Removal	20 ppm	D2700xH3700	2755 m³ (727,794 gal)	2640 m³ (697,414 gal)	860	516	556
With CO_2 Removal (Forced Draft Tower)	8 ppm	D2400xH3350	2723 m³ (719,341 gal)	2640 m³ (697,414 gal)	620	372	450
With CO_2 Removal (Liqui-Cel)	1.5 ppm	D2100xH3300	2702 m³ (713,793 gal)	2640 m³ (697,414 gal)	466	278	376

Notes:
1. Forced Draft Tower outlet CO_2 was set as 8.0 ppm taking into account seasonal temperature fluctuations impacting the tower performance in cooler weather.
2. 3M™ Liqui-Cel™ CO_2 outlet was set at 1.5 ppm to reduce the capital costs of the system. Lower CO_2 outlets are achievable and may be considered depending on the needs of the plant.

Table 2: Chemical Costs Per 110 m³/hr System

System Configuration	30% HCL Consumption (metric ton)	HCL Cost[1] RMB (USD)[3]	NaOH Consumption[2] (metric ton)	NaOH Cost[4] RMB (USD)	Total Regeneration Cost[4] RMB (USD)	Total Yearly Regeneration Cost[4] RMB (USD)
Without CO_2 Removal	1.416	878 (129)	0.516	1032 (151)	1910 (280)	697,150 (102,209)
With CO_2 Removal (Forced Draft Tower)	1.070	663 (97)	0.372	744 (109)	1407 (206)	513,555 (75,292)
With CO_2 Removal (Liqui-Cel)	0.842	522 (75)	0.278	556 (82)	1078 (158)	393,470 (57,686)

Notes:
1. HCL costs based on 620 RMB/metric ton ($91/metric ton)
2. NaOH costs based on 2000 RMB/metric ton ($293/ metric ton)
3. Conversion rate for RMB to USD was 0.14661 on 11/2008
4. Total costs are based on 365 days/year

Disclaimer:
Dollar and yuan values were obtained in 2008, and have not been adjusted for inflation.

Lanxess Lewatit 4.17 software was used to size the mixed beds and calculate the chemical consumption for three 110 m³/hr system designs:

1. RO + Mixed Bed (Current System)
2. RO + Forced Draft Tower + Mixed Bed
3. RO + Liqui-Cel + Mixed Bed

The software was validated by comparing the actual chemical consumption at the plant to the chemical consumption calculated by the software. The calculation was verified as matching the actual operating consumption.

As shown in Table 2, the chemical cost savings of using a membrane system are over 120,000 RMB (17,593 USD) per year compared to a traditional deaeration system. This figure does not include costs associated with wastewater treatment and the additional water required to operate the larger ion exchange systems. Additional capital savings may come from the smaller beds required by 3M™ Liqui-Cel™ Membrane Contactor systems.

Membrane systems have additional benefits. The membrane acts as a barrier between the gas and liquid phase, preventing particles and other contaminants in the air from contaminating the RO permeate. This is especially important in an environment where a deaerator may not be practical due to ambient air contamination. The membrane system is also modular and can be easily expanded to meet increased demand for plant water.

For additional information, please contact your 3M representative or visit 3M.com/Liqui-Cel.

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