

Degassing Boiler Feed Water in China with 3M™ Liqui-Cel™ Membrane Contactors

Introduction

ShenLan Environment Inc. located in Shanghai, China uses 3M™ Liqui-Cel™ Membrane Contactors in their boiler feed water treatment systems. These systems realize lower operating costs with the added benefit of reducing the chemicals added to the boiler feed water.

Background

Proper treatment of boiler feed water is an important component of a boiler system. As steam is produced, dissolved solids become concentrated and deposited inside the boiler. This leads to poor heat transfer and reduced efficiency of the boiler. Dissolved gasses such as oxygen and carbon dioxide will react with the metal surfaces inside the boiler, promoting corrosion. Degassing is an important step for protecting the boiler.

Liqui-Cel membrane contactors offer many advantages over forced draft deaerators, vacuum towers, and chemical treatment programs for feed water treatment. Membrane contactors utilize microporous membranes to create 10X the surface area compared to mechanical technologies. Contactors are highly efficient and compact and can be used inline under pressure.

Chemical Treatment

Chemical treatment is widely used to control dissolved oxygen in a boiler. The cost of operating a chemical



Figure 1. Membrane Contactor Boiler Deoxygenation System built by Shen Lan

treatment program consists of chemical costs and blow down costs. Periodically, the water in the boiler must be flushed out to remove non-volatile compounds. They are flushed out of the boiler in a process called blow down. Chemical addition to the water can increase the frequency of blow down, which increases the operating cost of the boiler.

There are two components of blow down costs. Water and steam that is purged from the boiler during blow down is sent to drain. This water must be replenished by fresh makeup water and there is a cost associated with it. The second cost is heat or energy cost. The water blow down from the boiler

is hot. It is replaced with cold water that must be reheated in order to produce steam.

Example Using Membrane Contactors

Membrane contactors can be used to remove the dissolved oxygen from water. By removing the dissolved oxygen, the volume of chemicals added to the boiler will be reduced. By reducing the chemicals added to the boiler, the frequency of blow down can be potentially reduced. The example on the following page (Figure 2) compares operating costs of two systems. One system is a chemical-only treatment system with a blow down rate of 10%.

The other system assumes that the oxygen content of the feed water is reduced to 0.5 ppm and that the blow down rate can be reduced to 5% due to the reduction of chemicals in the boiler.

The boiler specifications used in this example are for reference. These calculations can be modified in order to apply them to boilers with different operating conditions.

Membrane System Operating Cost

A 3M™ Liqui-Cel™ Membrane Contactor system can be used to produce feed water with low levels of dissolved oxygen. The operating cost of a membrane degassing system is comprised of electricity and seal water for the vacuum pump.

When comparing this to the chemical treatment system, annual savings reach \$2,170. When the savings associated with blow down is included, the operating cost savings can be more than \$8,500 per year. A typical membrane system designed to degas the water outlined in this example can have a payback in less than two years. The details and equations used to calculate the operating savings can be found in the full technical paper on this subject. This paper is available at 3M.com/Liqui-Cel in the technical resources section.

Figure 2. Comparison of Chemical Treatment System to Degassing System

	Chemically Treated Feed Water	Degassed Feed Water	Savings
Boiler capacity	10,000 lbs/hr	10,000 lbs/hr	
Pressure	50 psig	50 psig	
Fuel	Natural Gas	Natural Gas	
Fuel cost	4.5 USD/1000 ft ³	4.5 USD/1000 ft ³	
Fuel efficiency	1000 BTU/ft ³	1000 BTU/ft ³	
Boiler blow down rate	10%	5%	
Hours of operation	6600 hrs/yr (275 days/yr)	6600 hrs/yr (275 days/yr)	
Feed water costs	1.2 USD/ 1000 gallons	1.2 USD/ 1000 gallons	
Sodium sulfite cost	0.5 USD/lb	0.5 USD/lb	
Feed water temperature	60°F	60°F	
Inlet dissolved O ₂	9.0 ppm	0.5 ppm	
Chemical cost	\$2,299.00	\$128.00	\$2,171.00
Blow down water costs	\$1,055.00	\$500.00	\$555.00
Energy cost due to heat loss in blow down	\$11,095.00	\$5,256.00	\$5,839.00
Total yearly costs/savings	\$13,997.00	\$5,669.00	\$8,565.00

Summary

Dissolved oxygen control in boiler feed water is an important process that protects the boiler from corrosion. Chemical treatment is often used to control the dissolved oxygen. Liqui-Cel membrane Contactors can be used to replace or supplement the chemical treatment program. The contactors can minimize the volume of chemicals added to the feed water and offer savings to the end user by reducing chemical as well as energy costs.

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

Technical Information: The technical information, guidance, and other statements contained in this document or otherwise provided by 3M are based upon records, tests, or experience that 3M believes to be reliable, but the accuracy, completeness, and representative nature of such information is not guaranteed. Such information is intended for people with knowledge and technical skills sufficient to assess and apply their own informed judgment to the information. No license under any 3M or third party intellectual property rights is granted or implied with this information.

Product Selection and Use: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. As a result, customer is solely responsible for evaluating the product and determining whether it is appropriate and suitable for customer's application, including conducting a workplace hazard assessment and reviewing all applicable regulations and standards (e.g., OSHA, ANSI, etc.). Failure to properly evaluate, select, and use a 3M product and appropriate safety products, or to meet all applicable safety regulations, may result in injury, sickness, death, and/or harm to property.

Warranty, Limited Remedy, and Disclaimer: Unless a different warranty is specifically stated on the applicable 3M product packaging or product literature (in which case such warranty governs), 3M warrants that each 3M product meets the applicable 3M product specification at the time 3M ships the product. 3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ARISING OUT OF A COURSE OF DEALING, CUSTOM, OR USAGE OF TRADE. If a 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price.

Limitation of Liability: Except for the limited remedy stated above, and except to the extent prohibited by law, 3M will not be liable for any loss or damage arising from or related to the 3M product, whether direct, indirect, special, incidental, or consequential (including, but not limited to, lost profits or business opportunity), regardless of the legal or equitable theory asserted, including, but not limited to, warranty, contract, negligence, or strict liability.

3M and Liqui-Cel are trademarks of 3M Company. All other trademarks are the property of their respective owners. © 2021 3M Company. All rights reserved.



3M Company
3M Separation and
Purification Sciences Division
13840 South Lakes Drive
Charlotte, North Carolina
28273 USA
Phone: +1 980 859 5400

3M Deutschland GmbH
3M Separation and
Purification Sciences Division
Öhder Straße 28
42289 Wuppertal Germany
Phone: +49 202 6099 - 0

LC-1059
70-2016-0215-1

Rev. 02/2021

3M.com/Liqui-Cel