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3M™ Liqui-Cel™ Membrane Contactors Improve Water Quality and EDI Performance

Electrodeionization

Electrodeionization (EDI) is a widely used water treatment process. EDI technology is an electrochemical process that uses ion selective membranes and an electrical current to continuously remove ions from water. The process uses ion exchange resin to remove the ions from the feed stream, producing pure water. A DC current continuously regenerates the resin.

This technology operates under the same principles as conventional ion exchange resin technology with the added benefit of being a continuous process free of regeneration chemicals.

EDI Feed Water Requirements

In order to maximize the performance of an EDI unit, proper pretreatment is required. EDI equipment suppliers have different guidelines regarding feed water requirements but generally the specification can be summarized on the chart to the right. (See Figure 1).

Carbon Dioxide and Conductivity

When ion exchange is used to polish reverse osmosis membrane (RO) permeate, CO_2 needs to be controlled.

This is true for conventional mixed bed ion exchange and EDI technologies.

Excessive CO_2 is the leading cause of an EDI system not meeting design specifications. CO_2 gas dissociates in water to form HCO_3^- and CO_3^{2-}. These ionic species will contribute to the total anionic load and should be added to the measured total. Overloading the anionic capacity of the EDI unit will lead to higher product conductivity and higher levels of weakly charged ions like boron and silica in the product water.

Feed water conductivity does not show a complete picture of the total ionic load in a water system. Conductivity measurement devices do not detect the full amount of weakly ionized species like carbon dioxide and silica. Suppliers have developed methods to quantify the total ionic load on the EDI system. Two methods are described below (Figure 4).

These calculations show that the inlet CO_2 will contribute a significant anionic load on the EDI system. For example, if the inlet water contains 5 ppm CO_2 and 1.5 ppm bicarbonate (HCO_3^-) as $CaCO_3$ this will add 12.24 ppm as $CaCO_3$ to the TEA and 13.3 Us/cm to the FCE.

Figure 1. Typical EDI feed water specification

Feed water Constituent	EDI Feed Limit
PH	5-9
Conductivity (uS/cm)	<20
Hardness (as ppm $CaCO_3$)	<1.0
TOC (ppm)	<0.5
Oxidizers (ppm)	ND
Metals (ppm)	<0.01 Fe, Mn
Silica (ppm)	<1.0
CO_2 (ppm)	<5.0

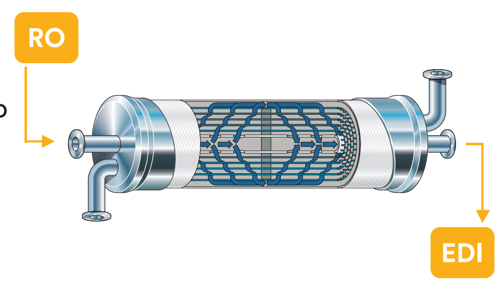

Figure 2. 3M™ Liqui-Cel™ Membrane Contactor

Figure 3. EDI Feed Water Specification – Ionic Loading

Feed water constituent	EDI Feed Limit
Total exchangeable Ion - TEA (as $CaCO_3$) (eq1)	<25
Feed water conductivity Equivalent - FCE (US/cm) (eq2)	<20

Figure 4. Equations

Equation 1	TEA as ppm $CaCO_3$ (Total exchangeable Ion) = TDS (ppm as $CaCO_3$, based on ionized species minus $HCO3^-$) + (ppm CO2 × 1.14 × 1.7) + (ppm $HCO3^-$as $CaCO_3$ × 1.7)
Equation 2	FCE as US/cm (Feed water Conductivity Equivalent) = (conductivity + ppm CO_2 × 2.66 + ppm SiO_2 × 1.94)

The most economical way to lower the load on the EDI is to remove a portion of the CO_2. This is illustrated below. (Figure 5).

Figure 5. Anionic Load

Anionic Load	5 ppm CO_2 / 1.5 ppm HCO_3	1 ppm CO_2/ 1.0 ppm HCO_3
TEA as CaCO3	12.2	3.6
FCE as Us/cm	13.3	2.66

EDI Pretreatment

EDI feed water pre-treatment is typically made up of softening and filtration using an RO system. These technologies can effectively remove particles, TOC, ions, and dissolved minerals from the water. Dissolved gases, however, are not effectively removed with these technologies.

Membrane Contactors

3M™ Liqui-Cel™ Membrane Contactors are widely used to remove dissolved gas from water. Liqui-Cel membrane contactors are hydrophobic membranes that allow a gas and a liquid to contact each other without mixing. By adjusting the pressure and concentration of the gas in contact with the liquid, dissolved gasses can be removed from water. A typical membrane contactor system designedfor CO_2 removal flows water on one side of the membrane; room air is drawn into the device under a vacuum on the other side. A schematic is shown to the right. (See Figure 6).

Liqui-Cel membrane contactors operate in-line under pressure and do not require surge tanks or transfer pumps. They can be installed downstream of the RO and upstream of the EDI unit to lower the CO_2 level to 1-5 ppm.

The Liqui-Cel membrane contactor system can be designed to lower the dissolved CO_2 to virtually any level required by the system. Additionally, as the ionic load is decreased, the power consumption of the EDI system can be reduced thus lowering the EDI operating costs. Furthermore, lowering the anionic load will improve the removal of the weakly charged anions like silica and boron.

Summary

Liqui-Cel membrane contactors are an important pretreatment process to an EDI unit. CO_2 can add significant ionic load to the EDI. Liqui-Cel membrane contactorsare compact, effective devices for removing the dissolved CO_2 gas in the feed water to protect the unit from being overloaded with anions.

These two membrane-based technologies are leading the way for a cleaner, more environmentally responsible process for producing purified water.

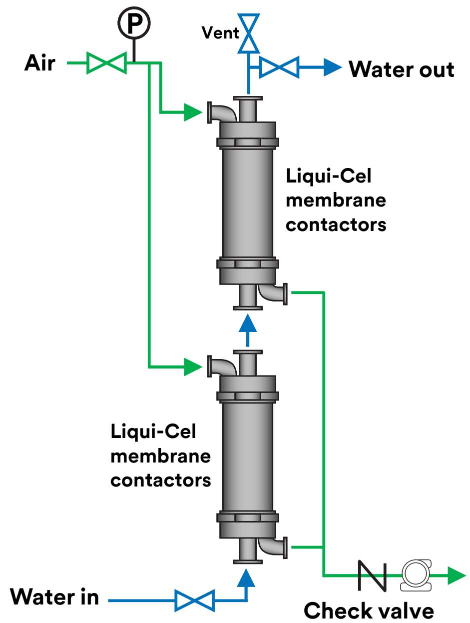

Figure 6. Schematic of membrane contactor system

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

References:

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LC-1060
70-2016-0238-3

Rev. 02/2021

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