PRODUCTS & APPLICATIONS FOR STEAM GENERATING PLANTS OVERVIEW

Liqui-Cel®
MEMBRANE CONTACTORS

ENGINEERED FOR EFFICIENT DISSOLVED GAS CONTROL

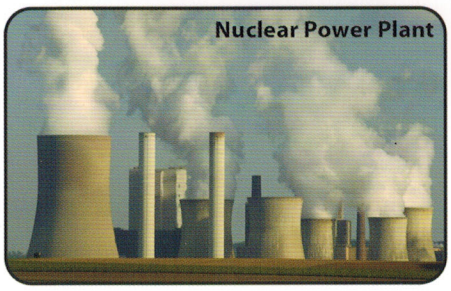
3M

THERMAL POWER PLANTS

When generating steam, dissolved gas control is an integral part of the water treatment system.

- Steam-electric power station uses steam to drive a turbine to generate electricity.
- Gas–fired power station uses hot combustion gas to drive a turbine to generate electricity.
- Combined cycle power station is a gas fired plant equipped with a heat recovery steam generator that produces steam to drive a turbine to generate additional electricity.
- A nuclear power plant is a thermal power station in which the heat source is a nuclear reactor. As is typical in all conventional thermal power stations, the heat is used to generate steam which drives a steam turbine connected to a generator which produces electricity.


Steam Plant


Nuclear Power Plant


HRSG

Historically vacuum towers, steam deaerators, decarbonators and chemical injection systems were common methods used to control dissolved gas in water systems in power plants. However, these methods can be much less efficient, require more maintenance and the handling of large volumes of chemicals.

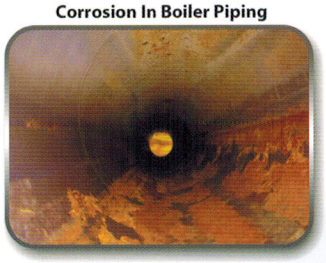
Liqui-Cel® Membrane Contactors can reliably achieve very low dissolved gas concentrations and operate with less chemicals compared to alternative degassing methods. Membrane contactors contain 10x the surface area of a conventional degassing tower and occupy a much smaller footprint.

WHY DEGASIFICATION IS IMPORTANT ?

Minimize Corrosion Inside The Boiler

Oxygen reacts with metals in the system and can cause pitting on the metal surfaces. Iron oxide produced during the corrosion process can promote iron deposits in the boiler. Carbon dioxide forms carbonic acid and enhances the corrosive effect of oxygen. Reducing dissolved O_2 will reduce corrosion in the boiler.

Corrosion In Boiler Piping



Reduce Mixed Bed Regeneration

CO_2 dissociates in water and adds to the ionic loading of the ion exchange equipment. Removing carbon dioxide can extend the run time between regeneration cycles 5-8 times. This reduces the chemical costs and waste water generated associated with ion exchange regeneration.

Pitting In Boiler Metal Surface

Improved EDI/CDI performance

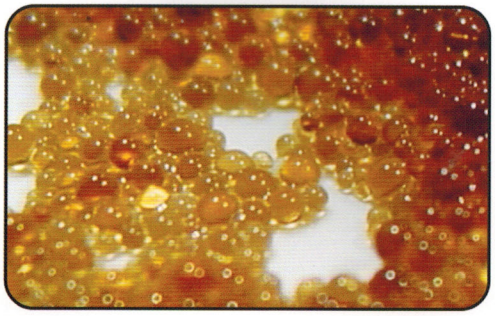
EDI technology combines ion exchange with an electric current to remove ions from water. Carbon dioxide will add to the total ionic load on the equipment and will be preferentially removed over weakly charged ions, reducing the performance of the EDI.

POWER PLANT APPLICATIONS

CO_2 Removal

As water treatment technologies have evolved from [Cation - Anion] exchange systems to [RO - mixed bed] and [RO-EDI] gas removal technologies, post RO have moved to membrane contactor degasification. Membrane contactor systems can remove carbon dioxide and reduce the ion exchange regeneration frequency in mixed beds which substantially lowers the chemical consumption and waste water treatment of the plant. This allows the plant to operate inside its permit and at the same time reduce the chemical consumption of the plant.

Mixed Bed Resin



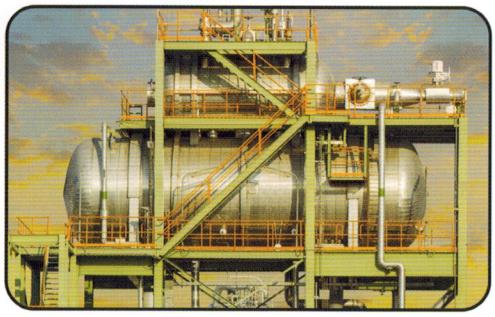
O_2 Removal

As steam demand increases and plants are modified to be operated at design capacity and above, conventional steam deareators can become overloaded and may not have the capacity to meet the higher water flow demands. Liqui-Cel® Membrane Contactors can be used to supplement the steam deareator at a significantly lower cost than installing an additional one.

Liqui-Cel® Membrane Contactors can also be used to eliminate the steam deareator. In these designs, the water is degassed using membrane contactors then pre-heated prior to the boiler using a latent heat recovery system. These plants realize significant energy savings by eliminating the steam used in the deareator.

Additionally, Liqui-Cel® Membrane Contactors can be used to remove dissolved oxygen from HRSG make up water during startup. This can reduce the anhydrous ammonia loss during the startup cycle when the steam deaerator (DA) vents are opened to vent the large amounts of dissolved oxygen in the cold make up water.

Steam Deaerator

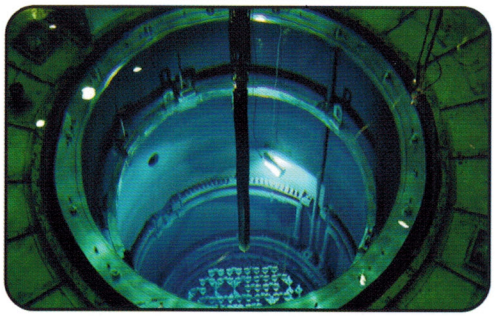


Chemical Storage Tank

AVT - All Volatile Treatment

Volatile treatment chemicals will vaporize first and will be vented in large quantities during this evolution. By supplying make up water as low as 1 ppb DO, the DA vent can be closed and the DA used as a feed water heater/storage tank. This also has the additional benefit of maintaining the volatile treatment chemicals in the system vs. venting them to the atmosphere and contributing to environmental limits, chemical usage, extra operator effort hours and operating costs.

Nuclear Reactor



Reducing The Formation of Radionuclides

Dissolved gas control in a nuclear power plant water system is essential to reduce the release of radioactive materials into the environment. Controlling dissolved gases can also help reduce the formation of unwanted radionuclides, such as ^{14}C and oxides of ^{60}Co and alleviate primary water stress cracking (PWSCC). Nitrogen and oxygen in the RMWST can also lead to the formation of ^{14}C and CRUD.

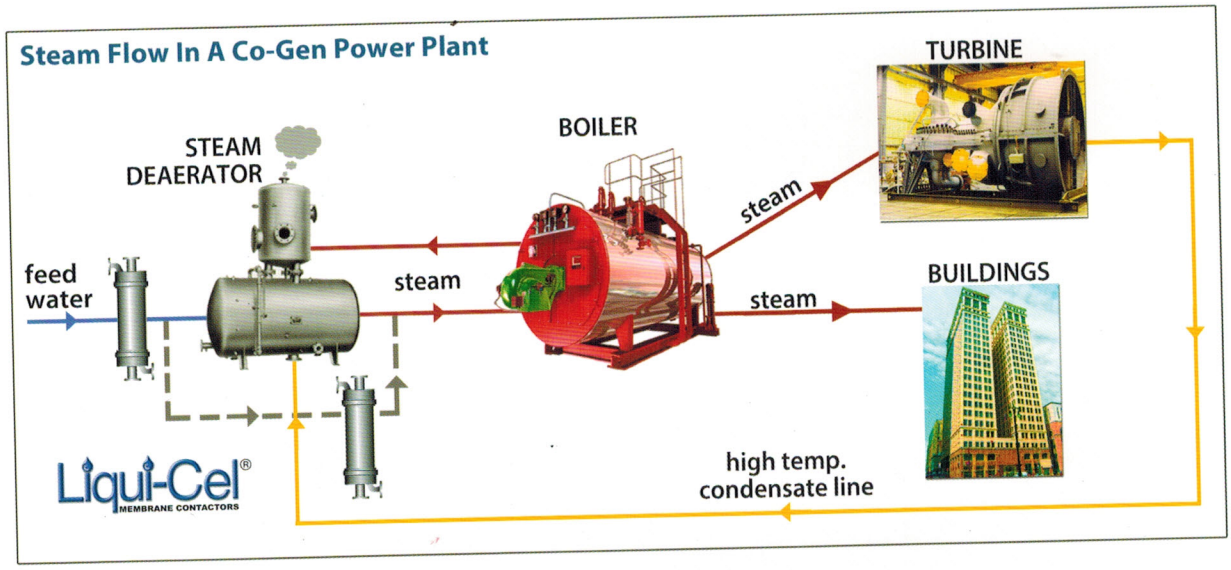
APPLICATION: O_2 Removal

REDUCE BLOWDOWN FREQUENCY - CONTROL CORROSION

Proper treatment of boiler feed water is an important component of a boiler system to control corrosion. As steam is produced, dissolved solids become concentrated and deposit inside the boiler. This leads to poor heat transfer and efficiency reduction of the boiler. Chemical treatment is widely used to control dissolved oxygen in a boiler. The cost of operating a chemical treatment program consists of chemical costs and blow down costs. Chemical addition to the water can increase the frequency of blow down, which increases the operating cost of the boiler. Membrane Contactors can be used to remove the dissolved oxygen from water with minimal chemical use. By removing the dissolved oxygen, the volume of chemicals added to the boiler will be lower which reduces the blowdown frequency.

REDUCE STEAM DEAERATOR VENT RATE - SAVE ENERGY

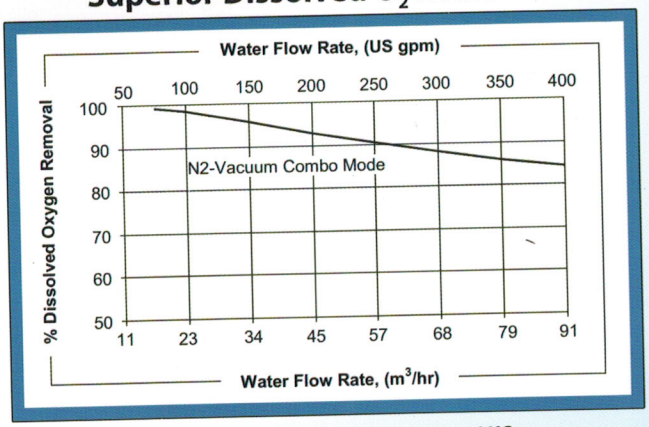
Power plants that generate steam require make-up to compensate for any water loss that may occur in the steam cycle. The amount of dissolved gas present in the make-up water is dependent on the temperature, which can vary by season. For example, in winter months, when steam is required for heating, the make-up water may be colder and contain more dissolved oxygen. The increase in dissolved oxygen may require an increased vent rate leading to additional steam loss and fuel costs. By incorporating a deoxygenation system using Liqui-Cel® Membrane Contactor technology, vent steam losses may be reduced or even eliminated depending on the plant's operation.



REDUCE CORROSION AT START-UP

Lowering the carbon dioxide ionic load on a mixed bed or anion bed may help decrease the regeneration frequency and reduce operating costs. Depending on the CO_2 level, water flow, tank size and other operating conditions, bed regeneration cycles can be reduced 2-3 times by decarbonating with Liqui-Cel® Membrane Contactor technology. Additionally, fewer cycles may also help power plant customers realize reduced chemical usage and wastewater generation associated with the ion exchange bed regeneration process.

Superior Dissolved O_2 Removal



Curves represent nominal values, generated using water at 20°C.
O_2 Removal: 14x28 inch, X40 membrane, N2-vacuum combo mode, vacuum: 75 mm Hg, N2 Sweep 0.5 scfm.

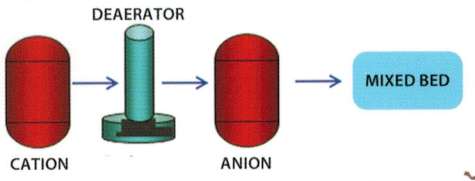
APPLICATION: CO_2 Removal

As RO membranes have become widely accepted in water treatment, they have replaced the traditional cation - deaerator - anion process to produce deionized water. RO membranes offer an economical way to deionize water without the added costs of chemical regeneration. However, carbon dioxide gas freely passes through RO membranes and will raise the conductivity of water and also lower the pH. Membrane contactors can remove carbon dioxide downstream of the RO membrane and greatly enhance the performance of the water system. By removing the carbon dioxide from the water, the ionic load on final polishing ion exchange equipment is reduced and the life of the mixed bed is extended. This will significantly decrease the regeneration frequency of the mixed bed. Customers report a 5-8x increase in service life. This offers significant savings in chemical, feedwater, waste water and labor costs.

Mixed Bed Demineralizer for a Power Generation Facility

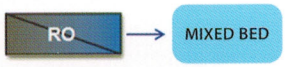
REDUCING THE SIZE OF THE IX SYSTEM CAN REDUCE CHEMICAL STORAGE ON SITE

TRADITIONAL ION EXCHANGE SYSTEM



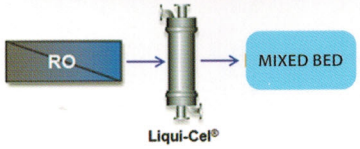
Cation and anion vessels remove ions from the water. Deareator removes carbon dioxide. Mixed bed final polishes the water and removes any remaining ions from the water.

RO MEMBRANE SYSTEM



RO removes ions and dissolved solids from the water. Carbon dioxide passes through the RO membrane. Mixed bed final polishes the water and removes any remaining ions from the water including ions formed from CO_2.

HYBRID MEMBRANE SYSTEM



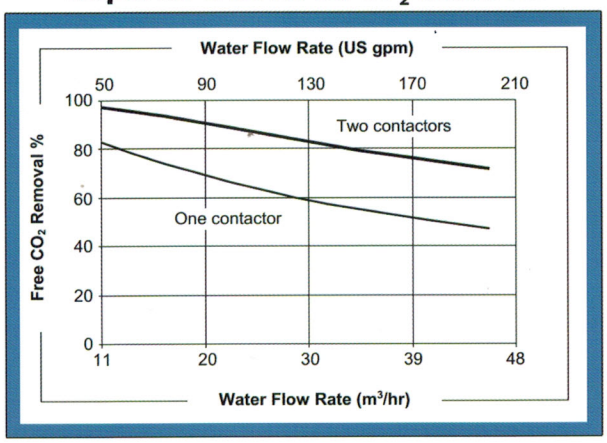
RO removes ions and dissolved solids from the water. Carbon dioxide passes through the RO membrane. Membrane contactor removes carbon dioxide. Mixed bed final polishes the water and removes any remaining ions from the water.

OPERATING COST SAVINGS

By lowering the carbon dioxide load on the mixed bed, the regeneration frequency can be reduced. This can have a significant impact on the regeneration costs. Depending on the CO_2 level and water flow rate a typical regeneration cycle may cost the plant $5,000-$7,000.

A 33 MW combined cycle in the US found that they were able to extend the regenerate frequency to once a month from once a week realized $250,000 a year savings in regeneration costs.

Superior Dissolved CO_2 Removal



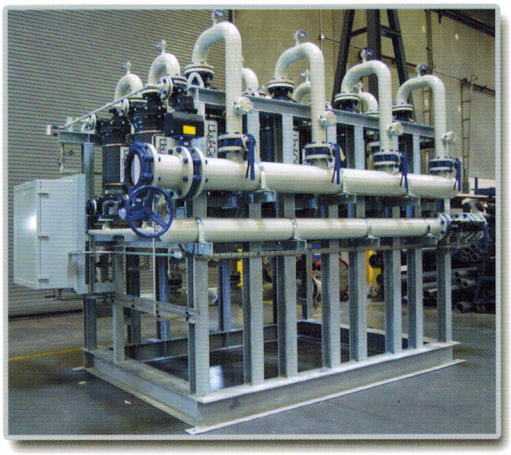
Curves represent nominal values, generated using water at 20°C. CO_2 Removal: 14x28 inch, X50 membrane, Air vacuum combo mode, vacuum: 150mm Hg, air sweep 8 scfm.

WHY LIQUI-CEL® ?

Economical

Liqui-Cel Degasification Systems:

- → Do not vent steam as an integral component of their operation ***Energy Savings***
- → Do not require the reinforced floor space and support steel required by a (ASME rated) steam deaerator
- → Operate with low electrical costs



14-inch Boiler Feedwater System

Flexible

Liqui-Cel Degasification Systems:

- → Can be custom configured to fit into pre-existing available space ***Mounting Location and System Integration Flexibility***
- → Can be added on for plant expansion and to accommodate increased production needs with minimal impact
- → Can be used as a temporary solution when the steam deaerator is not available

High Performance

Liqui-Cel Degasification Systems are engineered to outperform steam deaerators and vacuum towers for gas removal, achieving DO levels as low as 1 ppb.

- → Lower DO levels require less chemical oxygen scavengers, allowing for higher cycles of concentration and less blow down. ***Chemical/Energy/Water Savings***

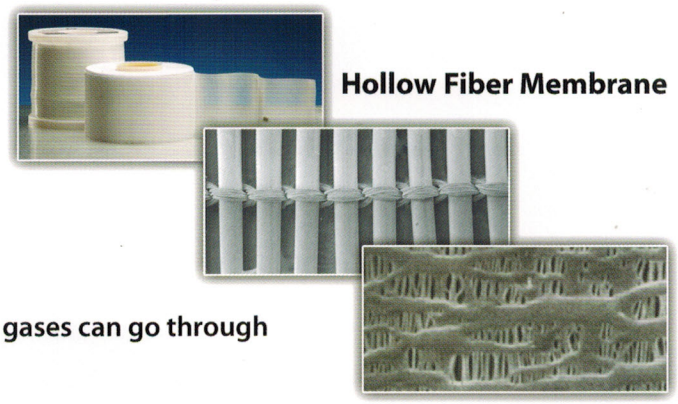
Reliable

Liqui-Cel Degasification Systems:

- → Typically designed with multiple trains of contactors, these systems can be fully automated and remotely monitored. With automatic switching and startup/shutdown features along with ease of upgradability, Liqui-Cel® can reduce your overall risk and add to the reliability of your system.

MEMBRANE

- Hydrophobic (Repels liquids)
- Acts as a support to bring the gas and liquid phases into direct contact
- Non-selective (between gases)
- Does not allow liquid to pass through the pores - only gases can go through



Hollow Fiber Membrane

SUPERIOR PERFORMANCE

10-inch Oxygen Removal System

Compact Design with 10x the Liquid-Gas Contact Area of A Conventional Degassing Tower

- Small Footprint
- Reliable, Predictable Performance
- Easily Adjustable for Water Flow Changes

8-inch Mobile Deox System

Adapts To Your Needs

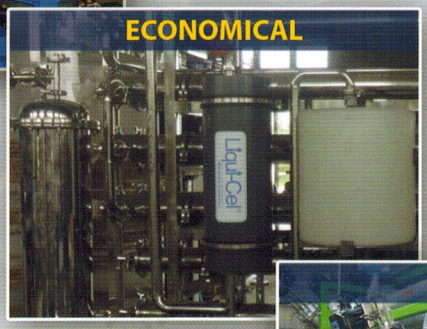
- Operate In-line
- Modular (Easily expandable after installation)
- Ideal For Mobile Systems

14-inch Industrial System

Membrane Contactors Operate Chemical-Free

- Lowers Ion Exchange Regeneration Chemicals
- May Help Reduce Need for Oxygen Scavengers
- Could Lower Disposal Costs

14-inch Deoxygenation System
in Power Plant



8x20-inch Industrial CO_2 Removal System
Using Blower

8x80-inch Mobile Deoxygenation
System in Refinery

Contact Us To Discuss Your Application.

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Industrial Business Group
Membranes Business Unit
13840 South Lakes Drive
Charlotte, North Carolina 28273
USA

Phone: +1 704 587 8888
Fax: +1 704 587 8610

3M Deutschland GmbH
Membranes Business Unit
Öhder Straße 28
42289 Wuppertal
Germany

Phone: +49 202 6099 - 658
Fax: +49 202 6099 - 750

3M Japan Ltd.
Membranes Business Unit
6-7-29, Kita-Shinagawa,
Shinagawa-ku, Tokyo 141-8684
Japan

Phone: +81 3 6409 5732
Fax: +81 3 6409 5827

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