



Integration of 3M™ Liqui-Flux™ Ultrafiltration and 3M™ Liqui-Cel™ Membrane Contactor Technologies

High Quality Water and Corrosion Control in a Cooling Water System at an International Amusement Park



In 2013, an international amusement park in Shanghai realized that they needed to improve the quality of their make-up to the cooling water circulation system to effectively control contamination, scaling and corrosion and to protect downstream system components. To accomplish its goals, the resort enlisted Goldstone to design and build a system using proven membrane technologies that effectively removed suspended solids, colloidal substances, chemical oxygen demand (COD), salt, and dissolved gases from the system. Ultrafiltration (UF), reverse osmosis (RO) and gas transfer membrane (GTM) technologies were included in the design.

For optimal results, Goldstone selected 3M™ Liqui-Flux™ W10 Ultrafiltration Modules as pre-treatment to reverse osmosis (RO) and 3M™ Liqui-Cel™ EXF-10×28 Series Membrane Contactor Membrane Contactors as the post-treatment to remove dissolved oxygen and carbon dioxide.

System Summary	
Application	Water Purification of Cooling Water
Location	Shanghai, China
OEM/System manufacturer	Goldstone
End-user	International amusement park
Design & Operating Specifications	
Feed water source	City water
Plant capacity	960 ton/day
Ultrafiltration	
3M™ Liqui-Flux™ W10 Ultrafiltration Modules	10 modules, RO pre-filtration
3M™ Liqui-Flux™ Ultrafiltration, Flux	65 LMH flux, 40 minutes
Outlet water quality specifications	SDI: ≤2
	Turbidity: <0.2 NTU
	Bacterial removal rate: ≥99.99%
Dissolved Gas Removal	
3M™ Liqui-Cel™ EXF-10×28 Series Membrane Contactor	8 pcs, O ₂ removal
Sweep gas	Nitrogen, 99.99% purity, <4 Nm ³ /h
Vacuum level	50 torr
Dissolved O ₂ inlet	8-9 ppm
Dissolved O ₂ outlet specification	<10 ppb



System Design

The entire system is designed to handle 960 ton/day of recirculated cooling water with two independent UF units with a capacity of 640 ton/day for each rack and degassing units with a capacity of 480 ton/day for each rack. Splitting the UF and degassing systems into two racks allowed for a more mobile and modular system design.

The UF plant is designed to operate with a 65 LMH flux with 40 minutes of filtration time and 250 LMH backwash flux. A backpressure above 2.0 bar is maintained due to downstream equipment requirements and piping demands. The feed water pressure is expected to remain above 3.5 bar. In operation, the feed water pressure is maintained at 4.0 bar and module tolerance pressure is 4.0 bar at 30°C. An in-line turbidity meter is installed for real-time monitoring of the outlet water and a chemical enhanced backwash (CEB) system is installed with a cycle time of once per day.

3M™ Liqui-Cel™ Membrane Contactors, also known as gas transfer membranes, were installed four in parallel and two in series to improve oxygen removal efficiency. The Liqui-Cel membrane contactor operates in combo mode (a nitrogen sweep gas and vacuum are applied to the degassing units) to further enhance gas removal efficiency.

Liqui-Cel membrane contactors can achieve a low dissolved oxygen concentration of <10 ppb, which is difficult with conventional gas removal processes. The compact design of the Liqui-Cel membrane contactors also enabled the system builder to design small skids.

Operation

The system was commissioned in June of 2014. The Transmembrane Pressure (TMP) of the ultrafiltration units is maintained between 0.18 bar and 0.20 bar during filtration. A Chemical Enhanced Backwash (CEB) cycle is performed daily with CEB1 and CEB2 running every other day. Since commissioning turbidity remains consistently at 0.03 NTU with an SDI15 of around 2.0. The produced water from the UF continues to fully meet the RO inlet water requirements.

Dissolved oxygen levels remain below 5 ppb, which exceeds the customer's expectations. In addition, the system only uses one quarter of the nitrogen sweep gas that was anticipated based on the original design, even when operating at full operating capacity. No chemicals are needed to operate the system.

The integration of 3M ultrafiltration and degassing membrane technologies before and after RO not only exceed design requirements, but continue to produce high quality water with low operating costs.

The 3M™ Liqui-Flux™ Ultrafiltration Modules easily tolerate the customer's pressure and harsh water requirements, and the Liqui-Cel membrane contactors continue to efficiently remove dissolved oxygen with minimal maintenance. The system outperforms traditional RO pre-treatment and gas removal processes. It also provides an efficient, cost effective solution for cleaning circulating water and reducing the risk of corrosion.



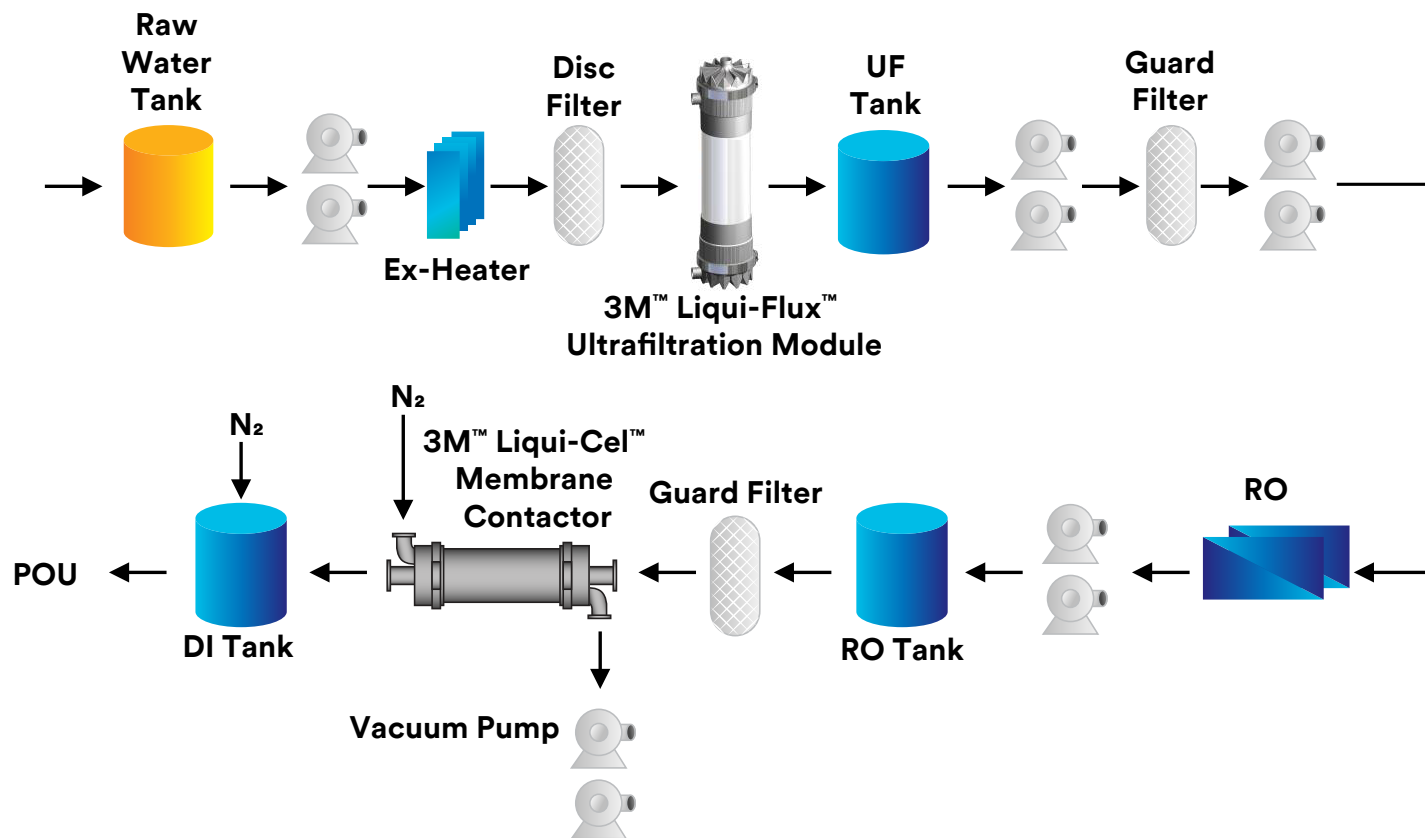
3M™ Liqui-Flux™ W10 Ultrafiltration Modules as pre-treatment to reverse osmosis



3M™ Liqui-Cel™ EXF-10x28 Series Membrane Contactor



Process Diagram



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Separation and Purification Sciences Division
 13840 South Lakes Drive
 Charlotte, North Carolina
 28273 USA
 Phone: +1 980 859 5400
 Fax: +1 704 587 8610

**3M Deutschland GmbH
 Separation and Purification Sciences Division**
 Öhder Straße 28
 42289 Wuppertal Germany
 Phone: +49 202 6099 - 0
 Fax: +49 202 6099 - 241

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