



USE OF ADVANCED THREE-STAGE MEMBRANE SYSTEM FOR TURNING EXTREME WASTEWATER INTO BOILER FEED WATER

Bruce Bishop Crosstek Membrane Technology



Introduction

- Crosstek is supplier of water treatment equipment and services
- Introduced to engine manufacturer starting upgrade of wastewater treatment process in 2018
- Manufacturer produces 300 to 500 diesel engines per day
- Production resulted in 50,000 gallons per day of wastewater
- Main sources of wastewater
 - Sanitary and grey water

- Cooling tower blowdown (CTBD)
- Oily metal working wastewater

2018 Treatment Process



New Unit Operations for Treatment Process

• Ultrafiltration (UF) unit to treat oily wastewater

- Membrane bioreactor to treat combined UF permeate and non-oily wastewater
- Reverse osmosis system to treat MBR effluent and recycle water back to production process

Projected Ceramic UF System Performance

• Key feed characteristics

- 800 to 2,300 mg/l total suspended solids (TSS)
- 1,000 to 1,500 mg/l emulsified oil and grease (O&G)
- System can generate 26,500 gpd of permeate in standard mode and up to 41,300 gpd in accelerated mode.
 - Standard mode: Weekly clean-in-place (CIP)
 - Accelerated mode: Daily maintenance cleaning and weekly CIP
- Weekly batch down for 83% to 95% water recovery (6X to 20X concentration factor) to minimize concentrate disposal
- Permeate TSS and O&G each less than 10 mg/l

UF System Characteristics

- 1,000-gallon skim tank and 200-µm strainer for pre-treatment
- Stainless steel feed, concentrate, and permeate piping

- 4 parallel banks of membrane modules each with 4 modules in series for a total of 16 modules
- 2 x 100% feed pumps, 2 x 50% recirculation pumps, and 1 x 100% backpulse pump
- Automatic dosing stations for cleaning chemicals









2022 Membrane Technology

> Ceramic UF system had a 40% lower 20year lifecycle cost than the competitive tubular polymeric membrane system.

Long-term Ceramic UF System Performance



Schematic of MBR and RO System Integration





MBR Feed Effluent	Units	Value
Ortho Phosphate, dissolved	mg/l	8.2
Chloride	mg/l	615.5
Fluoride	mg/l	5.3
Phosphorous, total	mg/l	9.2
Silica, dissolved	mg/l	28.6
Sulfate	mg/l	252.5
Barium	mg/l	507.5
Calcium	mg/l	153.5
Magnesium	mg/l	24.5
Sodium	mg/l	432
Alkalinity, HCO_3 as $CaCO_3$	mg/l	45.2
Ammonia, as Nitrogen	mg/l	5.1
рН		7.5
Silt Density Index (15 min.)		4 - 5
Chemical Oxygen Demand	mg/l	260 – 1,170

High Recovery RO System Approach

- Spacer Tube Reverse Osmosis (STRO) membranes
- High pressure capability up to 120-bar feed pressure
- Tolerant of solids and organics
 - SDI_5 of 5 (SDI_{15} not measurable)
 - COD of > 1,000 mg/l

2022 Lembrane

- 315 ft² of membrane surface area per spiral element
- Available with either brackish water or seawater membranes
- RO system includes recirculation to enhance performance

STRO Membrane Module Configurations



Single STRO Membrane Module (ST-L-ROX)

2022 Membrane Technology



Membrane Skids with Double Length STRO Modules (ST-DBL-ROX)

Conceptual STRO System Schematic



80% Recovery STRO System Design

- 100% saturation of BaSO₄ and CaF₂, TSS taken out in MBR
- Multiple scaling compounds
- 2 ppm antiscalant

- Feed pressure < 150 psig
- Permeate TDS < 133 mg/l
- Use 12 ST-DBL-RO3 brackish water RO membranes with space for 6 expansion modules
- 36,472 gpd feed treated, 29,178 gpd permeate for recycle and 7,294 gpd of concentrate
- As designed, saves up to 10,500,000 gallons per year of water

90% Recovery STRO System Design

- 100% saturation of BaSO₄ and CaF₂, TSS taken out in MBR
- Multiple scaling compounds
- 10 ppm antiscalant

- Feed pressure < 230 psig
- Permeate TDS < 220 mg/l
- Use 12 ST-DBL-RO3 brackish water RO membranes with space for 6 expansion modules
- 36,472 gpd feed treated, 32,825 gpd permeate for recycle and 3,674 gpd of concentrate
- As designed, saves up to 11,900,000 gallons per year

Considerations for Higher Recovery Design

• Approximately 44% more power

- Approximately 100% more cleaning chemicals and cleaning water but not labor intensive due to equipment automation
- Five times more antiscalant dose
- STRO is the only spiral RO technology that can achieve 90% recovery in this high organics application

Installed STRO Membrane System



2022 Vembrane

> STRO was selected over conventional RO due to 15% higher recovery leading to significantly less ion exchange regeneration chemical cost and improved safety for the production staff

Design Meets Reality

- Plant opted for 20 days per month of operation instead of 30
 - System expansion capability to meet total flow if necessary
- MBR supplier would not allow flux variation to level out feed flow to RO
 - Equalization tank size increased from 800 gallons to 50,000 gallons
- Plant stopped using coagulant in MBR for phosphate removal
 - Effluent pH increased and caused $Ca_3(PO_4)_2$ scaling
 - Antiscalant change and acid dosing to reduce pH used to solve phosphate scaling
- Plant insisted on using citric acid for pH reduction due to safety concerns in handling mineral acid
 - Resulted in bio-fouling of cartridge filters and membranes
 - Changed to low concentration mineral acid

Long-term STRO System Performance



Current Plant Wastewater Treatment Process

2022 Membrane Technology



Through in-plant process improvements and updated wastewater treatment process, output to POTW can be reduced by over 90%

Water Samples from Updated Process



Summary

- Engine producer upgraded wastewater treatment process starting in 2018
- New plant included ceramic UF, ceramic MBR, and STRO treatment with objective to recyle over 10,000,000 gallons of water per year
- New unit operations are operating successfully
 - UF for 3 years; RO for 2 years

2022 embrane

• Engine plant installed process capable of reducing operational cost, improving plant safety, and decreasing water discharge by over 90%

Thanks for your attention

CROSSTEK

• Bruce Bishop, (781-572-1875)

- Stanton Smith, (617-460-9433)
- Job Omweno, (603-502-4052)