1.0 Silicon Carbide Ultrafiltration System

1.1 Treatment System Description

The proposed membrane system will consists of membranes rated for 4 micron in a dead-end configuration. Dead-end configuration was chosen due to the quality of the water, oil and grease and total suspended solids (TSS) concentration.

- Membrane material: Silicon Carbide
- Housing material: Stainless Steel
- Piping: Stainless Steel
- Pore size: 4 µm

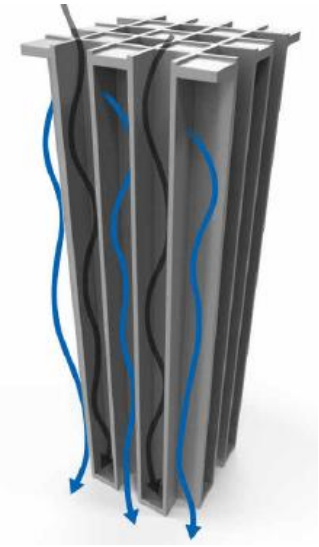

Figure 1: Membrane wall trapping for dirt, bacteria substances

Our filters provide full automation with backwashing only done on the basis of the trans-membrane pressure (TMP). Thereby reducing water usage, daily supervision and maintenance. The advanced control system allows you to control any other component, saving you time and money. The unit will be fully integrated, skid mounted with interconnecting stainless steel piping, feed pump, backwash pump, dosing pumps, backwash tank, instrumentation, clean in place system (CIP) and control panel.

1.2 Silicon Carbide Membrane Description

The substrates as well as the selective layers of ceramic membranes are made from 100% Silicon Carbide (SiC), which results in several unique advantages. The membranes are chemically inert (resistant at pH 0-14), highly resistant to elevated temperatures (up to 800°C or 1472 °F) and are furthermore hydrophilic (water loving). These properties make SiC membranes ideal for harsh applications and gives the membrane elements a long lifetime. In the scanning electronic microscope (SEM) shown in *Figure 2* the base structure, the support structure and the selective layer are shown, and all are made from 100% SiC.

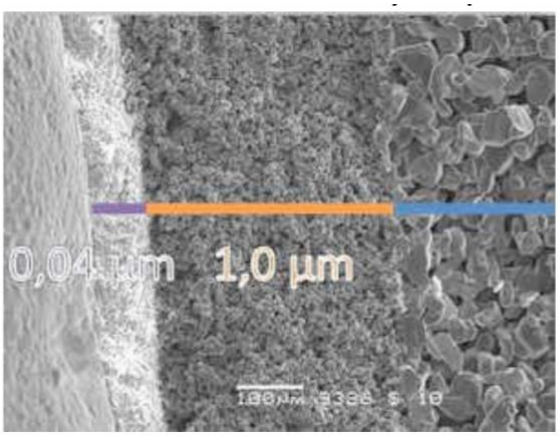

Figure 2: Membrane Electronic Scanning Microscope

The dead end ceramic 4 micron membrane system is an engineered filtration barrier that allows an effective barrier against suspended solids, dissolved solids and metals, heavy organics and hydrocarbons (oil and grease). The system is designed to be automated requiring minimal operator intervention.

1.2.1 Silicon Carbide Membrane Properties & Advantages

Silicon carbide UF membranes selected are **chemically resistant in the full pH range of 0-14**, and thus are **fully resistant to any of the chemicals of concern in the inlet fluid (<5mg/L).** Please refer to Table 2 below for a complete list of SiC membrane properties.

Figure 4: Size comparison between sand filter (right) and Ceramic filter

- Due to the high flux of the SiC Ceramic membranes, these membranes have a small footprint as the requirements for large pumps, valves and piping are minimum. This is especially of high importance for very large feed flows to be treated and in cases where space is a limiting factor.

- SiC membranes have the highest capacity of any membrane on the market. This is due to the high porosity of the SiC structure and the hydrophilic properties of the material. The contact angle with water of the material is very low, which gives the lowest resistant to transport of water. Furthermore, the circular channel design has optimum resistance to residue build up contributing additionally to the high flux.

- Energy consumption - the SiC membranes have a higher permeability (flow per m2 membrane area) compared to any other membrane technology, so the SiC membrane system operates at a lower energy consumption compared to other membrane technologies

- Chemically inert - No limitations across the pH spectrum, fast cleaning, reduced down time during Cleaning in Place (CIP)

- Thermally resistant up to 8000C (1472 °F) - Steam cleaning, more efficient chemical cleaning, and high temperature applications

- Extremely hard and durable material 2930 (Vickers scale) +/- 46,240,000 lb/in³ - Long life time, less down time and maintenance, stable operation, hard membrane surface not destroyed by sharp particles

- Stable with Solvents and Oxidizers - Will perform with any concentration of chlorine or ozone. Completely stable with any type or concentrate of solvents & oxidizers.

- Clean water consumption – the SiC membrane system will require less clean water needed for cleaning the full scale system compared to sand/media filters - typically only 20% of that volume. Besides clean water savings, the recovery (volume of treated water against volume of feed water) is typically higher for membrane systems compared to media filter systems.

- No Replacement of filter media – the SiC membrane system does not require continuous replacement of filter media – the SiC membranes are expected to have a lifetime of more than ten years. Granular based adsorption processes requires replacement and continuously addition media to the filtration system, which can cause the operating costs to increase significantly.

- Reduced volume of wastewater reject – the full scale system is expected to have a recovery rate is approx. 95-98% and to produce a waste stream (concentrated solids and bacteria) of approx. 2-5% of the feed volume. This volume can be further reduced to <1% with an optional dewatering module.

1.2.2 Silicon carbide versus conventional membranes

Table 2: SiC versus conventional ceramic versus other filtration methods

	Ceramic	Regenerative	Sand	Catridge	VAC DE	Vac sand
Automated system	+		+			
Uses less water for backwash	+	+		+		
Uses less chemicals	+			+	+	
Minimizes crypto	+	+				
Take up less space	+			+		
15+ year warranty	+	+				
Uses no media	+					
Removes organic and inorganic material daily	+				+	
Fully non-corrosive construction	+			+		
Filters down to 3 micron	+	+		+		
24/7 monitoring	+		+			
Control filter from anywhere in the world	+					
Fits through a 3x6 ft. doorway	+			+		
Minimal installation labor	+					
Pre-installed electrial and control	+					
Monitors temperature	+					
Monitors flow	+					
Montors pressure and pressure drop	+					
Option for pH, chlorine and more	+					

The table below emphasizes the differences between **UF membrane** materials. Polymeric membranes are commonly used because of its low manufacturing cost and hence, a lower initial capital cost. But due to the lack of key characteristics that are in contrast found in a Silicon Carbide material, the operating costs is substantial from the frequent fouling and membrane replacement, low flux rate (i.e. requiring a bigger footprint) and a lower permeate recovery rate.

	MEMBRANE MATERIAL		
Type	SiC	Al2O3	Polymer
Life time	+++	++	+
Flux	+++	++	+
Chemical resistance	+++	++	+
Energy savings	+++	++	+
Recovery rate	+++	+++	+
Fouling tendency	+++	++	+
Relaxation time	None	None	Yes
Temperature resistance	+++	++	+
Hardness	+++	++	+
Porosity	+++	++	+

Table 3: SiC Membranes versus conventional membrane materials

2.0 System Operation

2.1 System Operation

The control operation is explained below. As the budgetary proposal, all drawing and diagrams are a representation of the system but do not depict the actual system. Official P&ID's and PFD's will be drafted once the budgetary proposal is reviewed and accepted by the client. Abbreviations used are as follows:

TMP: Trans-membrane pressure
CIP: Clean in place
Recovery: Ratio of permeate flow and feed flow
LMH: L/m2.h = indication of production
LMH/bar or L/m2.h.bar = indication of membrane permeability
FV: Automatic on/off valve.

2.1.1 Permeate Extraction operation

Feed water enters the system through inlet valve via VFD controlled feed pump. The water is then pumped into the system, passing the flow transmitter and a pressure transmitter. The flow transmitter is controlling the inlet flow to the system, based on the level in residual water transfer tank.

Water is distributed via manifold and via on/off feed valves to the ultrafiltration membrane racks. During permeate extraction the bleed off valves and backwash valves will be closed.

The water then flows through the wall of the membranes and enters as permeate via the permeate valves. Permeate continues to the permeate outlet or the permeate tank.

The pressure prior to membrane racks is measured by a pressure transmitter, whereas the pressure after the membranes (permeate side) is measured by a subsequent pressure transmitter The TMP is calculated for each rack and accordingly, each rack can individually run a CIP or back wash cycle.

2.1.2 Backwash operation

Backwash is an automatic way of cleaning the membrane by means of the backwash pump. Membrane must be back washed with 500 LMH for a duration of 10 seconds. The backwash system is designed to flush the system and clean for any residual waste inside the filter from the feed water. The backwash can be done in 3 ways, two automatic ways, and one manual, these are:

1. If backwash is set to 'Time' and a time value is set, a backwash will be initiated with the set time intervals.
2. If backwash is set to 'TMP' and a TMP is set, a Backwash will be initiated with the set TMP value.
3. A backwash can also be initiated manually; this is done by pressing the BF button on the main screen of HMI.

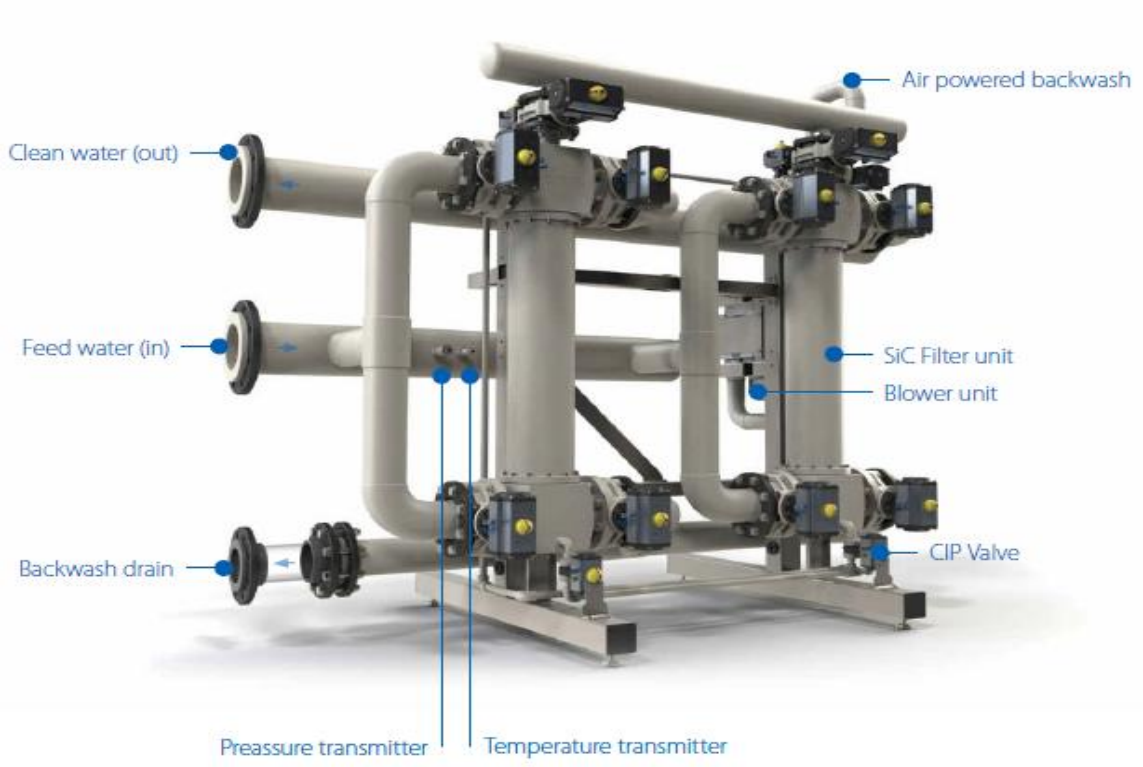

Figure 5: Process Flow Schematic

6.1.3 Clean in Place (CIP) Operation

Clean-in-Place (CIP) is a method of cleaning the interior surfaces of pipes, vessels, process equipment, filters and associated fittings, without disassembly. It needs chemicals to remove the buildup of foulants such as mineral scale or organic material. The usual CIP consists of two types of cleaning. First, a high pH solution (caustic solution) is circulated to remove organic and biological foulants such as bacterial slimes. Then, after the first solution has been flushed out a second low pH solution (acidic solution) is circulated to remove mineral scale. Whether start with a low pH solution or a high pH solution is dependent on the application.

During this step, heater in CP tank is turned on until the CIP solution reaches the temperature as defined in the CIP PLC/HMI control panel. The duration of this step is also defined by the user in the

CIP PLC/HMI control panel. When circulation step has come to an end, the bleed off valve opens and CIP valve closes. In that way CIP liquid in pumped to the drain.

Operation Configuration: the system is fully automated in terms of filtration/cleaning modes, which reduces the need for supervision and maintenance.

2.2 System Monitoring

H2O's UF systems has the ability to monitor key parameters, such as flow, pressure and temperature, which can be proactively controlled by the system to maintain a continuous performance, i.e. through adjustment of trans-membrane pressure, back flushing and chemical cleaning. The data collected by the system will be available for the customer so that H2O Systems can address any ongoing performance and maintenance issues promptly. The system can be remotely monitored and controlled and is supplied with full system overview on HMI interface.