FILPURE ULTRAFILTRATION PROCESS DESCRIPTION

Process Operations

The basic operating conditions for the FILPURE Ultrafiltration modules are shown in Table A below. The process operating parameters for the cleaning steps are provided in the cleaning section.

Table A : FILPURE Ultrafiltration Operating Conditions

Operating Conditions	SI	US
Feed Pressure, Maximum at Inlet at 20 °C	6.25 Bar	93.75 psi
Operating TMP (Maximum)	2.1 Bar	30 psi
Filtrate Flux @25 °C	40 - 120 L/m²/hr	24 - 70 gfd
Temperature (UPVC limited)	1 – 40 °C	34 - 104 °F
Operating pH Range	2 - 11	
NaOCl, Cleaning Maximum	2,000 ppm	

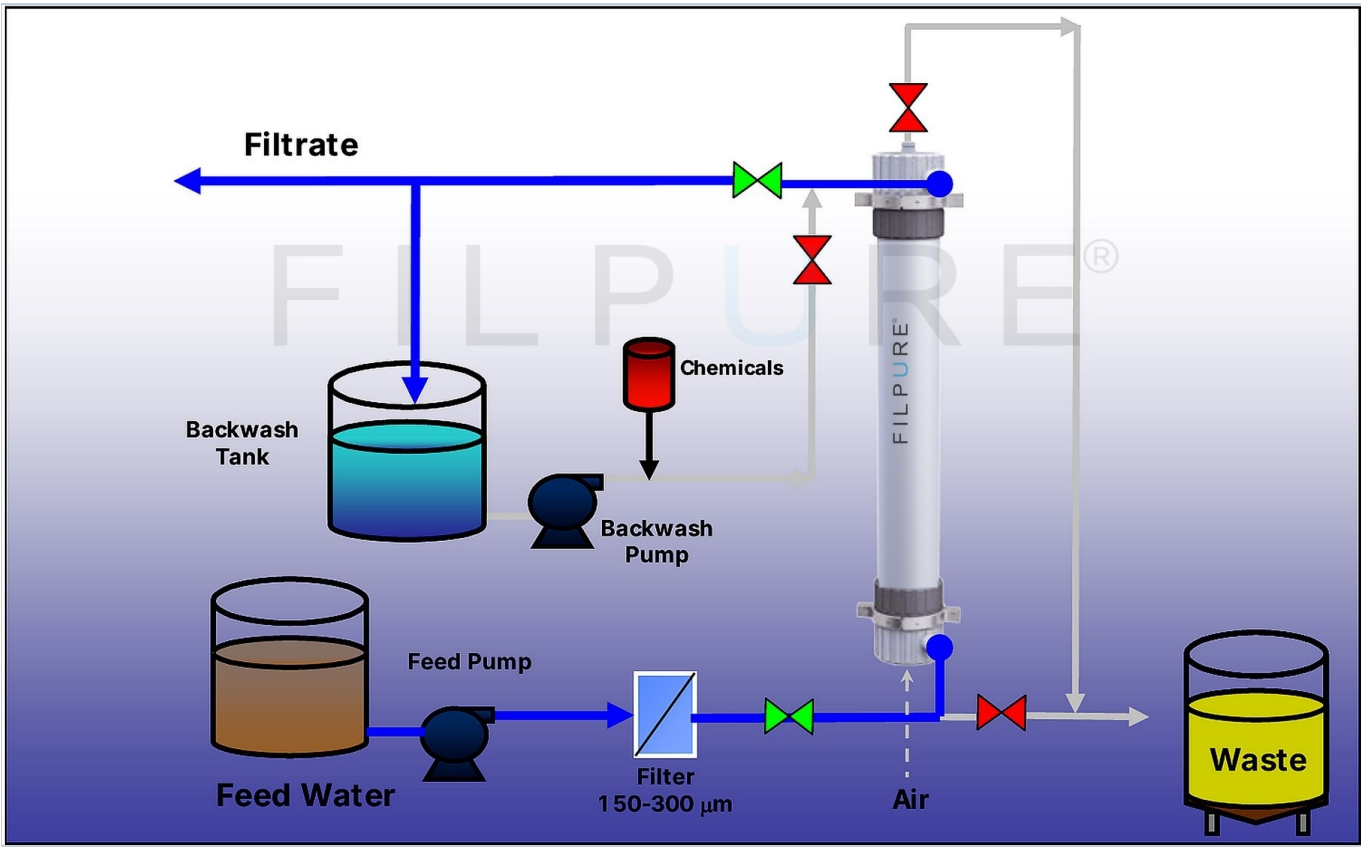


Figure 1: Filtration Step for FILPURE UF Modules

Normal operation refers to the routine operating sequence of a system using the FILPURE Ultrafiltration module and includes the operating and backwash steps. At initial start up the modules are flushed using a "forward flush" to remove any residual chemicals or trapped air from the module. The flush occurs on the outside of the fibers and does not filter the feed water to make filtrate. After the forward flush is discontinued the modules can be placed in the operating mode. An operating cycle ranges from 20 to 60 minutes. While operating 100% of the feed water is converted to filtrate. As contaminants are removed during the operating step the transmembrane pressure will rise. At the end of the preset operating cycle time, a backwash sequence is triggered.

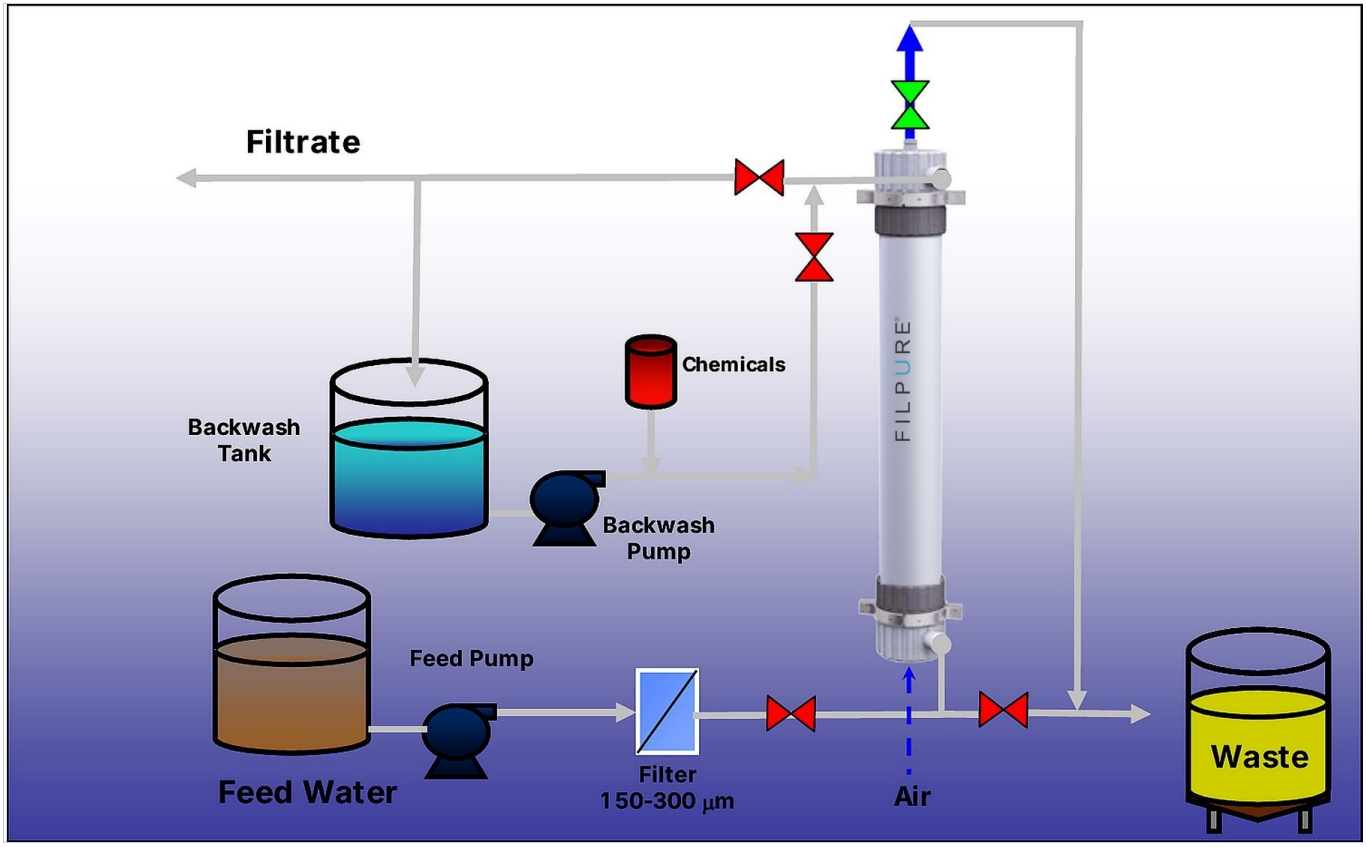


Figure 2: Air Scour Step for FILPURE UF Modules

The backwash mode occurs automatically and may include an air scour, but always includes draining, backwash through the top drain, backwash through the bottom drain, and a forward flush. The air scour step, when included, is used to loosen particulates deposited on the outside of the membrane surface. Air is introduced on the outside of the fibers and displaced feed flow/concentrate is allowed to discharge through the top of the module for disposal. After 20 to 30 seconds of air scour the module is drained by gravity to remove dislodged particulates. If the air flush is not included, the backwash sequence is started with simply draining the module by gravity to remove the concentrated feed water before starting any backwashing.

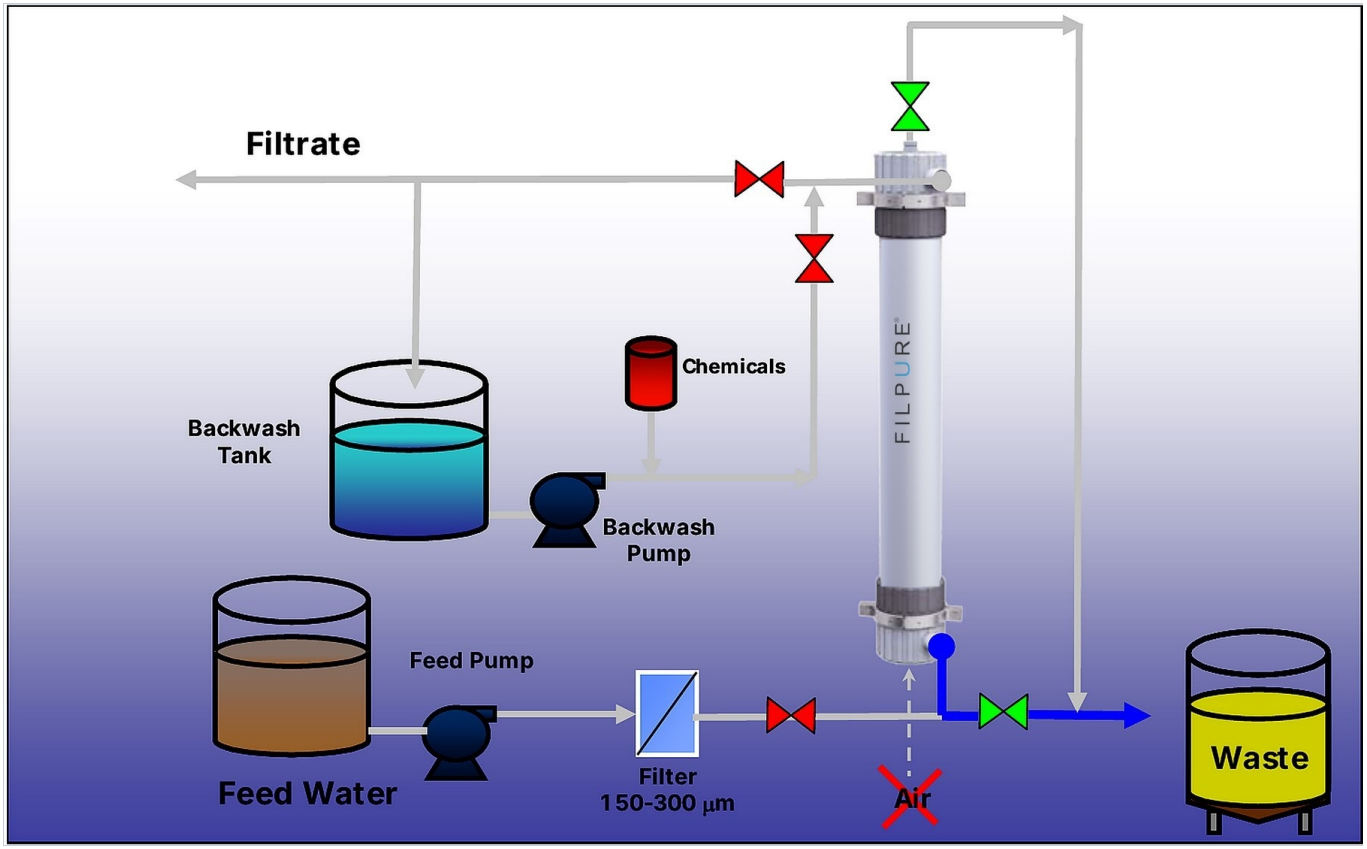


Figure 3: Module Gravity Drain Step After Air Scour for FILPURE UF Modules

After draining the first backwash step is performed. Filtrate flow is reversed from the inside of the fiber to the outside and backwash flow is removed from the module housing through the top drain on the module. A top draining backwash is performed first to remove contaminants in the area of greatest concentration.

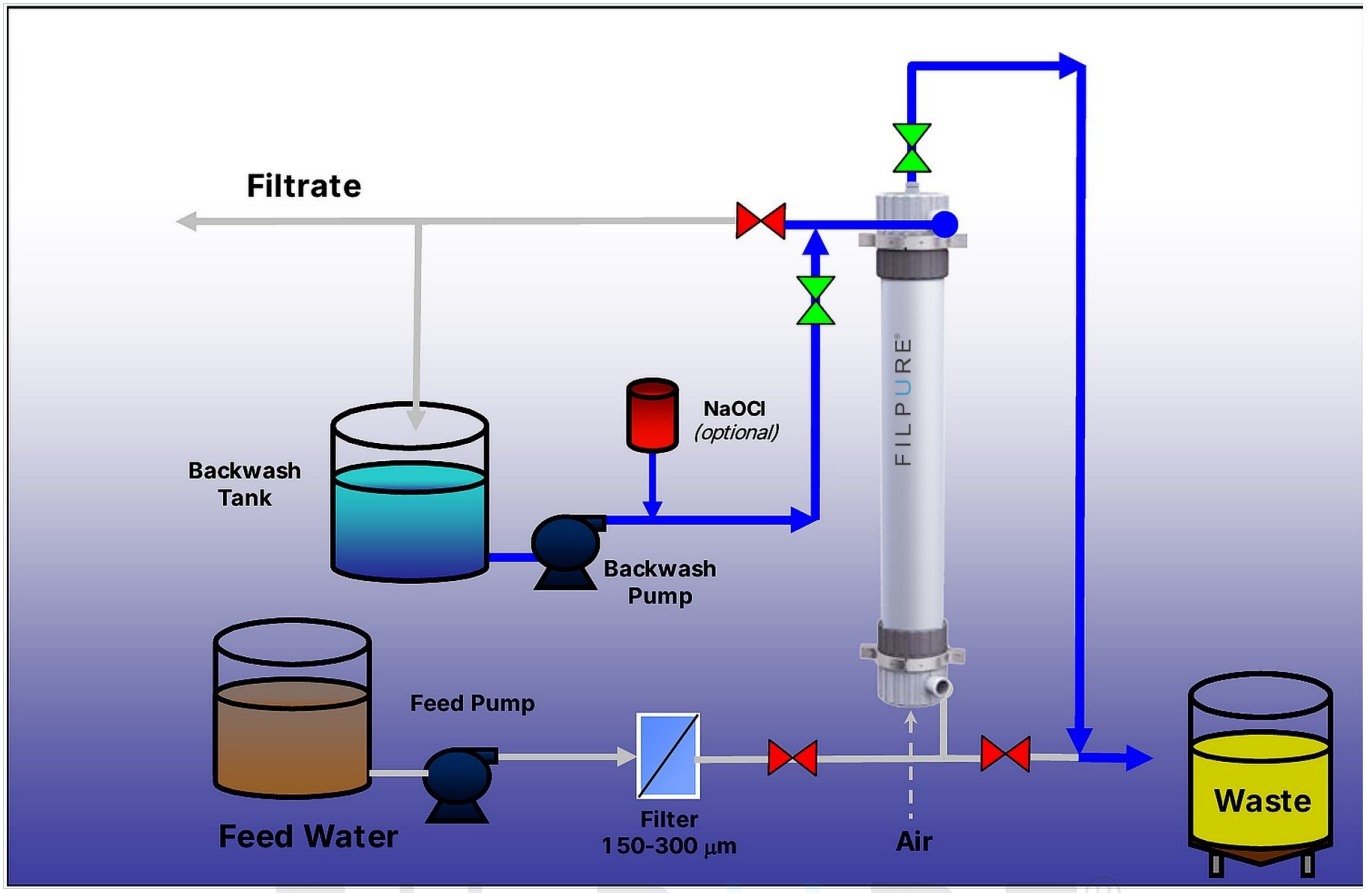


Figure 4: Top Backwash Step for FILPURE UF Modules

The second backwash step is performed to remove contaminants through the bottom of the module housing. Filtrate flow is reversed from the inside of the fiber to the outside and backwash flow is removed from the module housing through the bottom drain on the module for efficient removal of heavier materials. The two steps of backwash can be repeated numerous times depending on the degree of fouling. After backwash is complete, a forward flush is performed to remove any remaining contaminants and remove any air trapped on the outside of the fibers. After a backwash, the modules are returned to the operating mode.

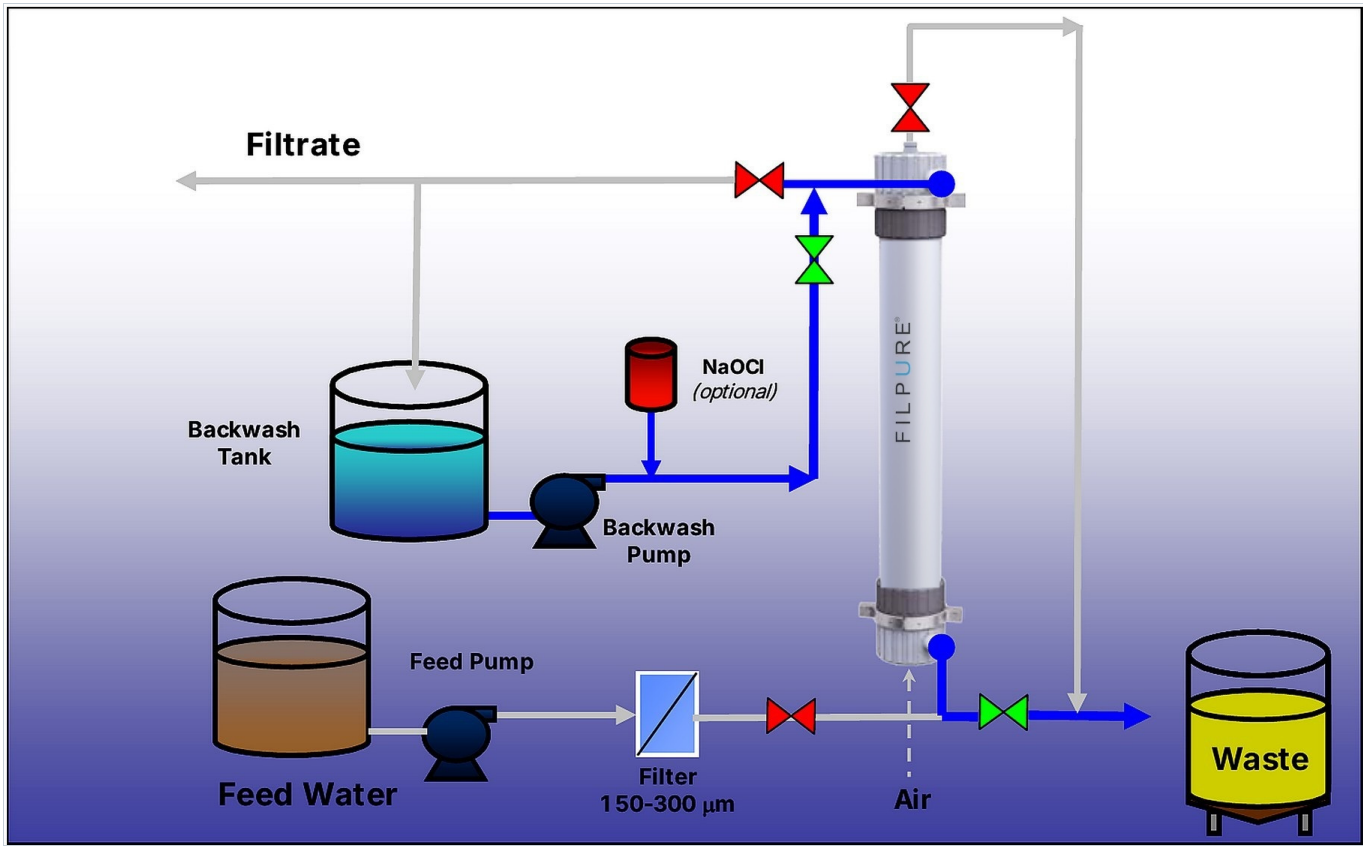


Figure 5: Bottom Backwash Step for FILPURE UF Modules

If the modules are taken out of service, the following steps should be taken: perform a backwash sequence, dose a chemical preservative to the modules, and close all valves on the modules.

CEB operation refers to a chemically enhanced backwash. The frequency of a CEB is dependant on the feed water quality. On high quality feed waters a CEB may not be required. The CEB process occurs automatically but the frequency can be adjusted after gaining operating experience. The CEB is performed using UF filtrate and either an acid or base combined with an oxidant is added to more effectively clean contaminants from the membrane surface. The choice of chemicals added is made according to the FILPURE Ultrafiltration projection software (UFlow) used in the design of the system.

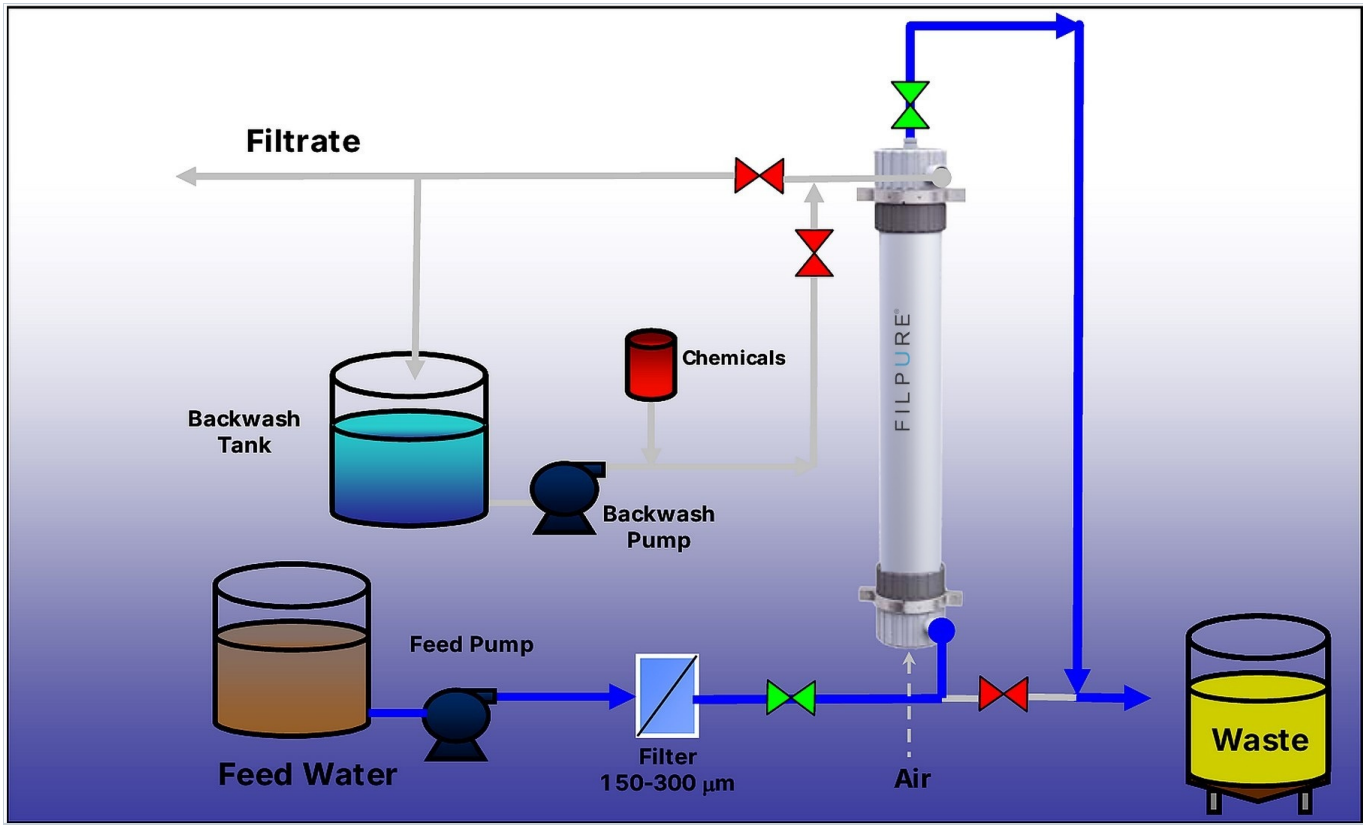


Figure 6: Forward Flush Step for FILPURE UF Modules

The CEB follows the steps of a normal backwash except a CEB chemical is dosed into the backwash water and a soak step is added after the second backwash step.

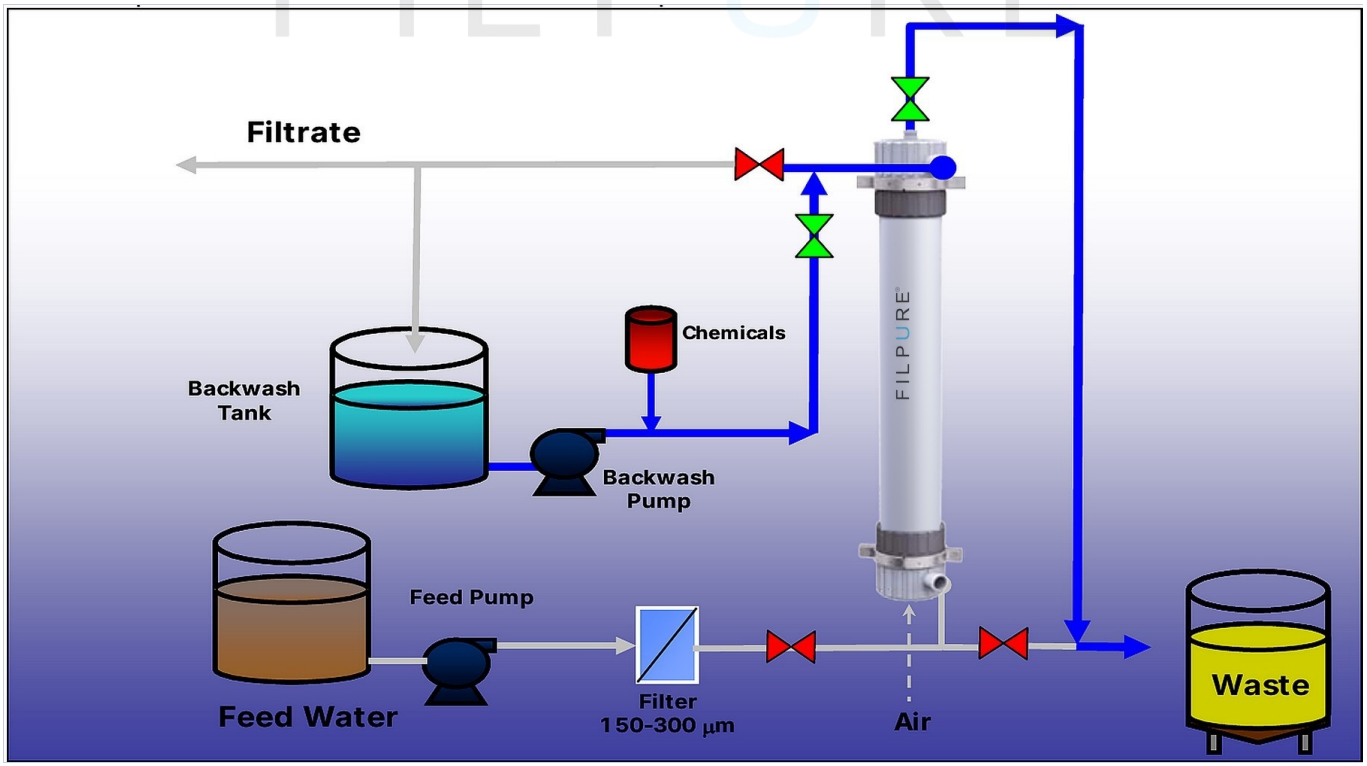


Figure 7: Chemically Enhanced Backwash "Top" Step for FILPURE UF Modules

The soak is performed for 5 to 20 minutes and allows more time for the chemical to react with contaminants that have attached to the membrane surface or penetrated the fiber wall. Intermittent air scour can be applied during the soak step. After the soak a routine backwash including air scour, top and bottom backwash, and forward flush is performed to remove any remaining particulates and residual chemicals. After a CEB and at the start of the

operating step, filtrate may be wasted to remove residual chemicals.

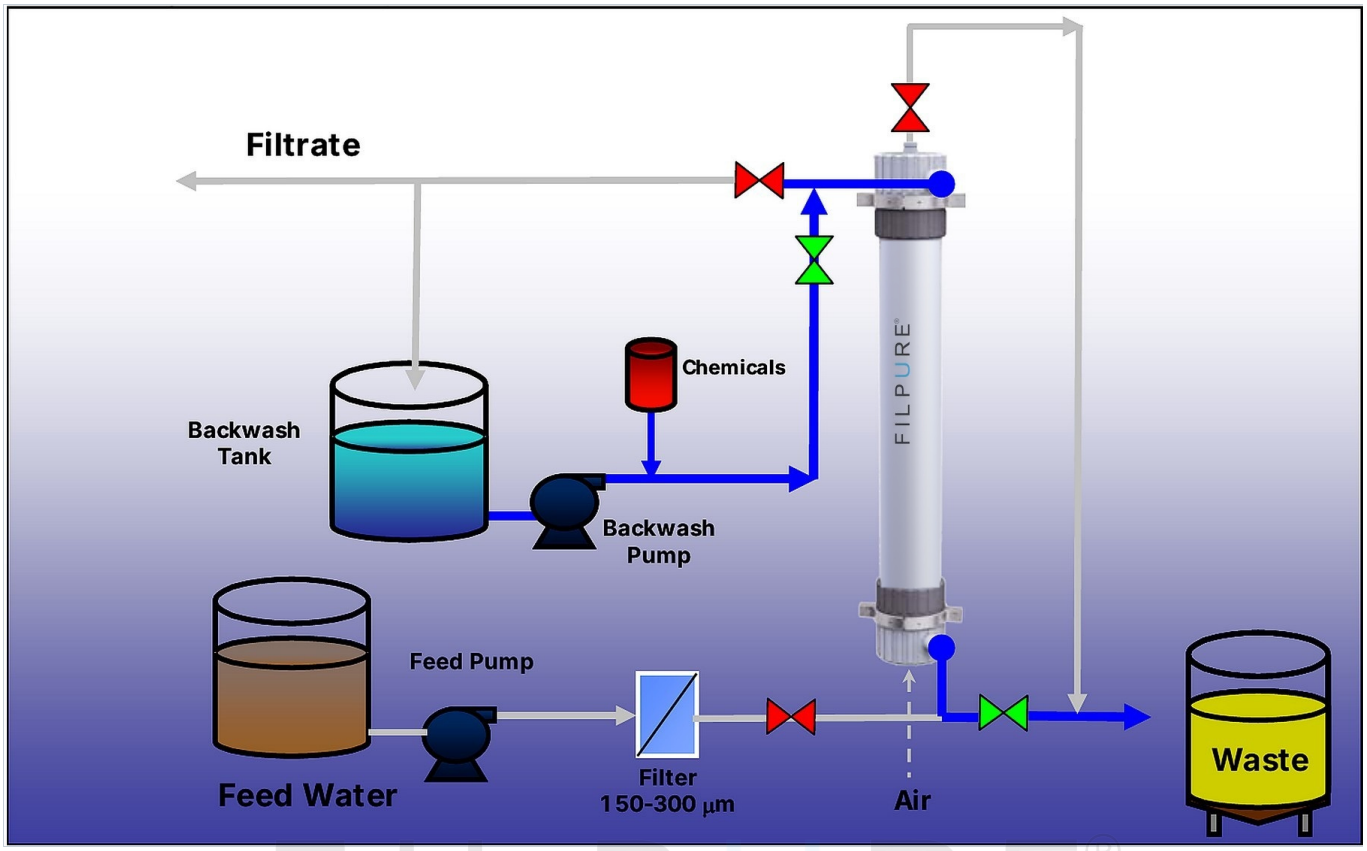


Figure 8: Chemically Enhanced Backwash "Bottom" Step for FILPURE UF Modules

CIP

A clean in place (CIP) operation includes backwash and chemical recycle to clean the fibers. The CIP is an on demand operation. The frequency of a CIP is dependant on the feed water quality but can range from 1 to 3 months. Prior to a CIP the routine backwash steps including air scour, draining, backwash through the top drain, and backwash through the bottom drain are performed. The backwash steps are repeated 3 to 8 times to remove contaminants or foulants not requiring chemical removal. After completing the backwash steps, the module is drained by gravity to remove excess water and prevent dilution of the CIP chemicals. CIP chemicals are recycled on the outside of the module for 30 minutes through the chemical cleaning tank. A small chemical filtrate stream will also be collected and recycled to the chemical cleaning tank. Note that the CIP solution can be heated up to 40 °C to improve its effectiveness at removing contaminants from the membrane. A soak follows the initial recycle step for 60 minutes or longer depending on the degree of fouling that has occurred. After the soak step, CIP chemicals are again recycled on the outside of the module for 30 minutes. When the recycle is completed an air scour is performed and then the module is drained to remove concentrated chemicals. The 2 steps of backwash and a forward flush are performed to remove any remaining contaminants on the outside of the fibers. After a CIP and at the start of the operating step, filtrate may be used to remove residual chemicals held in the fiber or module. The CIP steps described above are for a single alkali or acid chemical solution. If an acid and alkali cleaning are required, the CIP steps would be repeated for each chemical solution.

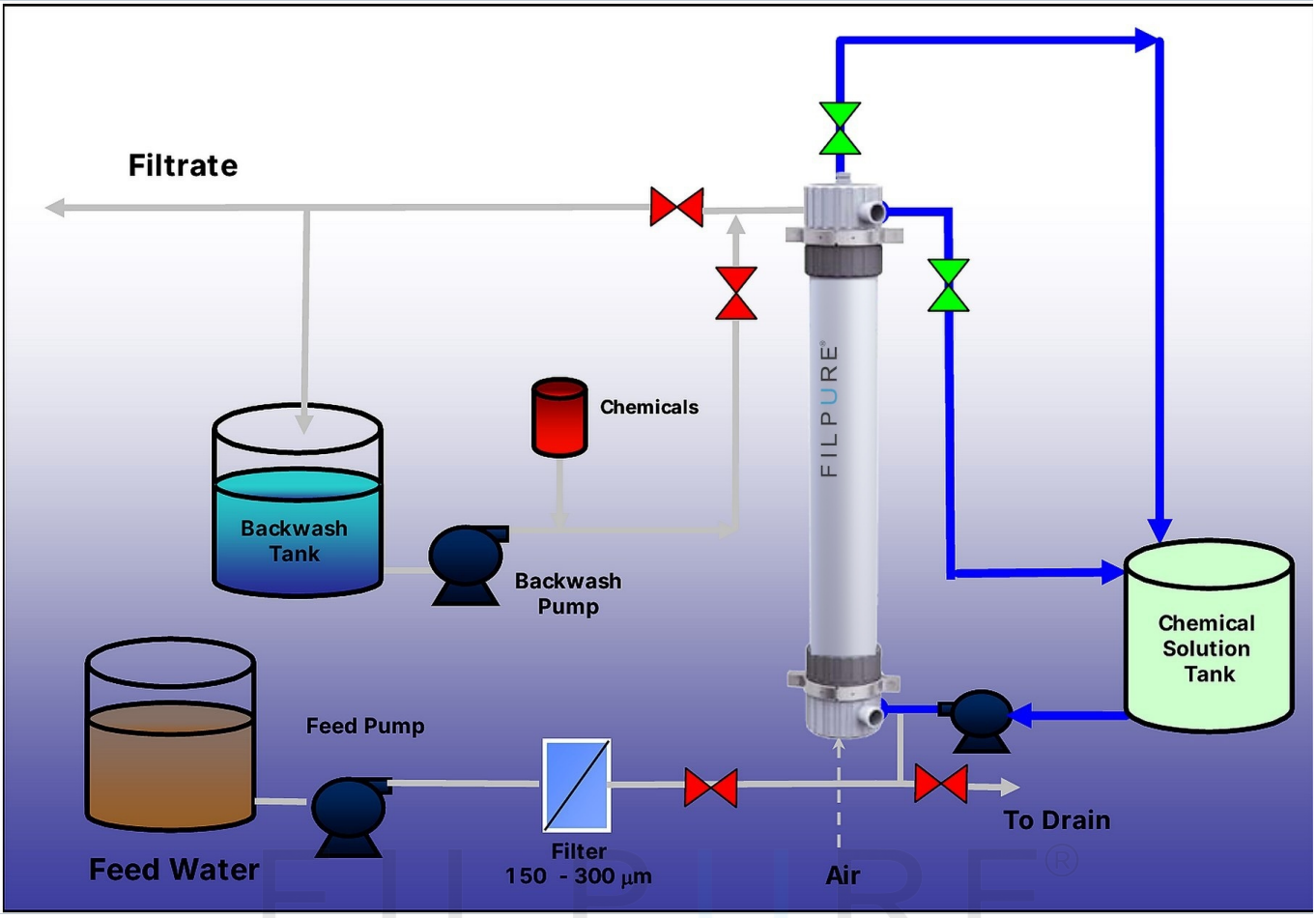


Figure 9: Clean In Place Cleaning Step for FILPURE UF Modules

Pretreatment

FILPURE Ultrafiltration module designs are based on qualified feed water conditions as shown in Table B. The UF modules can tolerate periodic excursions in feed water quality as shown as the maximum allowable. If the feed water quality is outside of the design basis range shown below a pilot study should be operated to confirm performance or pretreatment must be considered. If the system is designed and installed to the conditions below but the feed water quality is not maintained, FILPURE Water & Process Solutions should be consulted.

Table B: Qualified Feed Water Quality Parameters

Parameter	Unit	Design Basis	Maximum Allowable
Turbidity	NTU	<50	300
TOC	mg/l	<10	40
Particle Size	micron	<150	300
COD(Mn)	mg/l	<20	60
Oil / Grease	mg/l	0	<2
pH continuous		6-9	2-11
Temperature	°C	25	40
Cl2 continuous	mg/l	0.5	200
TSS	mg/l	50	100

Depending on application, a safety screen of 150 – 300 microns is recommended on the feed to the UF system. A variety of technologies can be used such as self-cleaning screens and bag, cartridge, or disc filters. Depending on the type of water or range of feed water parameters other pretreatment technologies such as oxidation, coagulation, sedimentation and media filtration may also be recommended.

Cleaning

Summary of Information

The process operating parameters for the cleaning steps are provided in Table C below.

Table C: Summary of Cleaning Processes

Process	Parameter	Value
Backwash	Frequency	Once every 20 to 60 minutes (water source or pilot test results)
	Duration	40 to 120 seconds
	Flux	100 to 150 l/m²·h (60 - 90 gfd)
	Maximum Inlet Pressure	2.5 bar (36 psi)
	Air Flow per Module	5 to 12 Nm³/h (3 - 7 scfm)
Air Scour	Duration	20 to 60 seconds per cycle
	Air-Water Mix Entrance Pressure	≤ 1.0 bar (14 psi)
	Air Quality	Non-oil compressed air
	Frequency	As needed
Chemically Enhanced Backwash	Duration	Backwash time plus soak 5 to 20 minutes
	Cleaning Solutions	0.1% HCl, 2% Citric, 2% Oxalic 0.1% NaOCl, 0.05% NaOH
	Frequency	When TMP exceeds 1.0 bar above starting TMP (at same temperature)
Clean In Place	Duration	120 minutes (recycle and soak) or longer
	Cleaning Solutions	0.2% HCl, 2% Citric, 2% Oxalic 0.1% NaOH + 0.2% NaOCl
	Cleaning Flux per Module	1.0 – 1.5 m³/h (6.6 - 8.8 gpm)
	Temperature Range	10 to 40 °C (34 - 104 °F)

Fouling

There are four types of fouling common to UF operations including particulate, biological, inorganic, and organic.

Particulate fouling is caused by suspended solids, colloids, and turbidity that can be reduced by coagulation, sedimentation, clarification, and media filtration. The common cleaning method for particulate fouling is air scour and backwash.

Biological fouling is caused by the growth of microorganisms that can be reduced by using in-line chemical feed of chlorine or biocide or by elimination of nutrients by using PAC, GAC, or coagulation. The common cleaning method for removal of biological fouling is Chemically Enhanced Backwash (CEB) with oxidizers or biocides (Cl2, H2O2, SBS).

Inorganic fouling is caused by the precipitation of inorganics on the membrane that can be reduced by using oxidation/precipitation and filtration as pretreatment to the UF or in some cases using low hardness water for the alkali chemically enhanced backwash. The common cleaning method for removal of inorganic fouling is chemically enhanced backwash with acid at pH 2 (HCl, H2SO4, Citric, Oxalic Acid).

Organic fouling is caused by organics adsorbing on the membrane (silt, organic acids, humus) that can be reduced by using PAC, GAC, or coagulation. The common cleaning method for removal of organic fouling is CEB with alkali at pH 12 (NaOH).

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