Anuket Hollow Fiber Ultrafiltration Membrane Module

Designing & Operating Manual

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Contents

Ⅰ.Brief introduction of ultrafiltration technology

Ultrafiltration(UF) is a kind of membrane separation technology which can purify and separate the solution. UF membrane system is a separation device based on the UF membrane as the filter medium, the pressure difference across the membrane as the driving force. UF membrane only allows solution of solvent (water molecules), inorganic salts and small molecular organic compounds to pass, and concentrate the solution of the suspended matter, colloid, protein and microbial macromolecular material withheld, so as to achieve the purpose of purification and separation.

At present, UF membrane is widely used in water treatment engineering. UF technology has played an increasingly important role in the field of reverse osmosis pretreatment, drinking water treatment and reuse of reclaimed water. UF technology also plays a key role in the sterilization and removal of turbidity of wine and beverage and the food and drug concentration process.

It has long been vague for UF filter pore size and interception molecular weight range, which are generally believed that the UF membrane filter pore diameter is from 0.001 to 0.1 micron, interception molecular weight (Molecular weight cut off) 1000 to 500000 Dalton. UF membrane which is usually used in the water indicates that it intercepts molecular 30,000～300,000 Dalton, while UF membrane which can intercepts molecular 30,000～60,000 Dalton is mostly used for pretreatment of reverse osmosis.

UF module is originally combined by the hollow fiber UF membrane, which can be connected with an UF system is called a super filtration membrane module. UF membrane module have external pressure type and internal pressure type based on operating model and structure of membrane.

The external pressure UF modules have characteristics of anti fouling performance. Anuket AK series UF products using external pressure structure design, combined with the Anuket anisotropic membrane structure and water distribution technology, Anuket AK series UF products obtained excellent performance of water treatment.

Ⅱ.Introduction of Anuket ultrafiltration membrane module

Anuket AK series UF modules are the most high-quality and efficient membrane products, which have used advanced international membrane technology. Anuket hollow fiber membranes are made of PVDF materials. Anuket UF modules are designed for an external pressure structure.

Anuket series of membrane modules can remove almost all of the particles, bacteria, most of the bacteria and colloids. Anuket anisotropic membrane structure and their single layer microstructure make Anuket series membrane module can keep a high practical running flux. Membrane modules usually run under a constant flow mode and stable trans-membrane pressure. Under this operating condition, by means of regular back washing and gas scrubbing method, contamination layer on the surface of the membrane can be removed easily. What’s more, effective control of microbial reproduction within membrane modules and more thorough removal of membrane surface contaminants can be achieved by adding bactericide in the back washing water.

Advantages of Anuket UF membrane:

a. Good hydrophilicity.

b. Strong chemical resistance ability, PH wide adaptation.

c. High strength, long life.

d. Single layer structure, cleaning easiness, good water flux recovery.

Based on above excellent performances，Anuket UF membrane modules have been widely used in power generation, electronics, metallurgy, food, medicine, medical treatment, petrochemical, biochemical, water reuse, seawater desalination and many other industries.

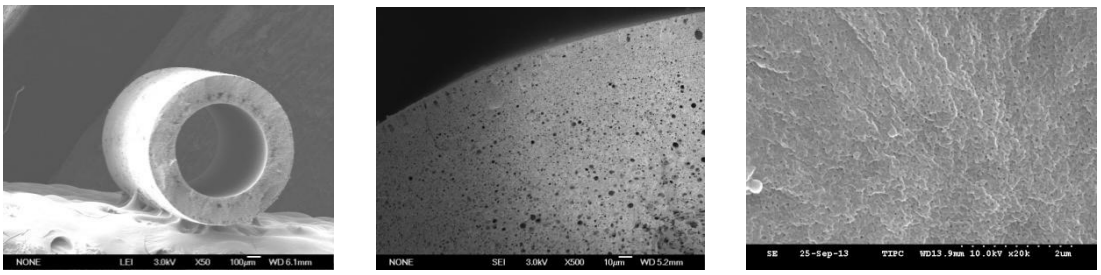
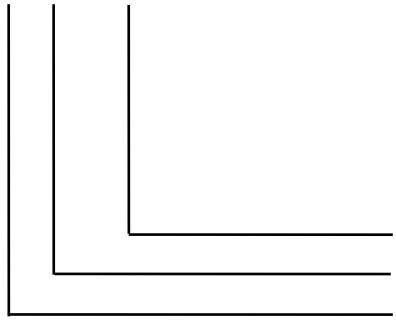


Figure 2.1 SEM photos of hollow fiber membrane

Meaning of name of the Anuket UF membrane module

AK X / X



The length of hollow fiber membrane modules, including the sealing part（mm）

Effective area of hollow fiber membrane module（㎡）

Abbreviation of Anuket

For example：AK70/2000 means that the area of hollow fiber membrane module is 70 square meter. The length of hollow fiber membranes in module is 2000mm. Anuket brand

2.1 The Specification and basic parameters of Anuket UF Membrane Module

Table 1 Basic parameters	
Product model	AK70/2000
Type of membrane structure	Hollow fiber anisotropic membrane, external pressure
Material of membrane	PVDF
Dimensions (mm)	Φ225×2358
Diameter of connecting pipe (mm) （Coupling）	Φ60
Area of membrane (m2)	70
Pore Size (μm)	0.05
Diameter of hollow fiber outside/inside (mm)	1.3/0.7
Average flux of purified water ①(L/m2 ħ)	300
Material of casing	ABS/UPVC/PMMA
Head adhesive	Epoxy resin
Weight of modules (kg) dry/wet	50/100
Capability	
Permeate water production ② (t/h)	2.5~4.5 t/h
Turbidity of permeate water ③ (NTU)	≤0.1NTU
Permeate water sludge density Index	≤2
Permeate water TSS	Not detected in water samples per 100 ml
Removal rate of virus	≥99%

1. Under the condition of 25℃, 0.10 MPa.
2. The feet water is raw water.
3. The turbidity of feed water is less than 50 NTU.

2.2 Anuket ultrafiltration membrane module outline dimension

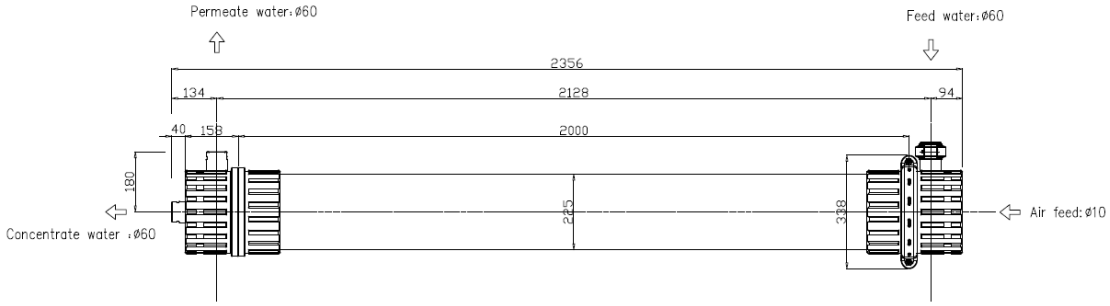


Figure 2.3 AK70/2000 components outline dimensions

2.3 Operation Conditions of Anuket Ultrafilitration Membrane Module

Table 2 Typical process conditions of membrane modules

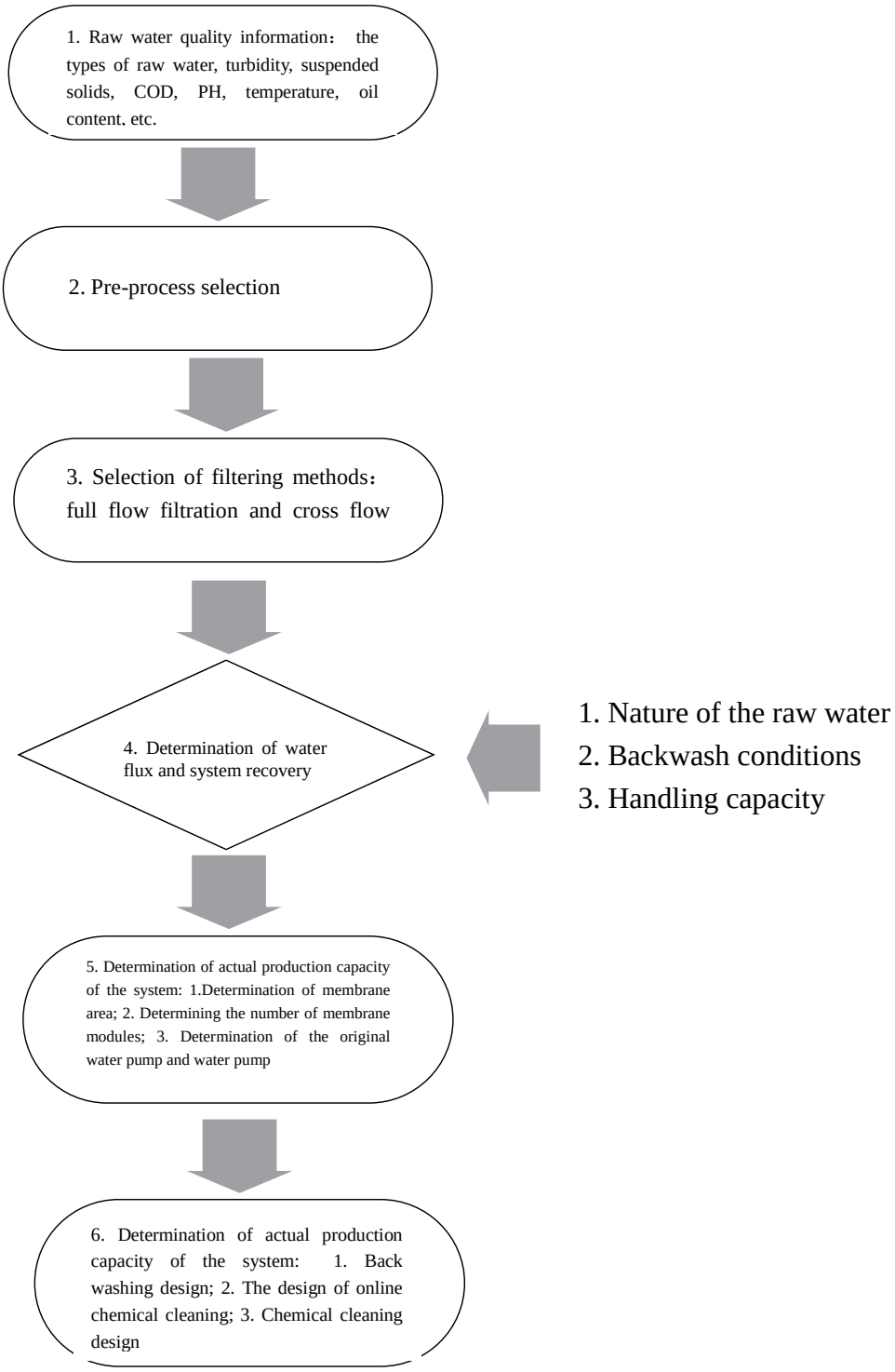
Recommended operating conditions	Raw water source	Tap water, groundwater, surface water, sea water or urban reclaimed water
	Designed flux (L/m2 ħ)	45~120 (Selected according to the water pretreatment)
	Maximum inlet water turbiility (NTU)	200
	Maximum feed water particle diameter (μm)	≤100
	PH range	2~11
	Temperature （℃）	8~40
	Maximum inlet pressure （MPa）	0.3
	Maximum trans-membrane pressure （MPa）	0.05~0.15
	Oil content （mg/L）	< 0.2
Backwashing	Backwashing period (min.)	Once every 30 to 60
	Backwash flux (m3/ h ŀModule)	5~8
	Back washing time (S/time)	30～60
	Maximum backwashing pressure (MPa)	0.2
	Positive flow rate	1~1.5 times to the design of water production
	Positive rush time (S)	10~30
Maintenance chemical cleaning	Cleaning frequency	One maintenance chemical cleaning should be done no more than 20 back washing cycle, generally determined by the test results
	Dosing back washing time(min.)	5 ~ 30 minutes, including soaking time

	Dosing concentration	100-500 ppm NaClO or 0.2% HCl
Air scrubbing	Gas scrubbing frequency	When the raw water suspended matter is higher, more than 50mg/L, membranes in module can be cleaned by gas scrubbing, once every 1~5 days for gas washing
	Single component air intake (Nm3/h)	6~12
	Gas washing time (min./time)	2~5
	Gas water mixed water penetration pressure (MPa)	＜0.1
	Gas source	Oil free compressed air
Chemical cleaning	Cleaning frequency	Clean once when trans-membrane pressure difference of the initial rises by 0.1 MPa (the same temperature) or flux decreases by about 20%, or system has operated six months.
	Chemical cleaning time (Min)	60 ~ 90 minutes (serious pollution can be properly extended)
	Chemical cleaning method	Pickling: HCl (0.5%), citric acid; alkali wash: NaOH+NaClO (500ppm)；
	Cleaning flow	1 ~ 1.5 times of the designed water flow
	Cleaning liquid temperature (℃)	25 degrees to 35 degrees (higher temperature helps to improve the efficiency of cleaning)
Integrity detection	Air pressure (MPa)	0.08

Note: The new Anuket UF membrane modules must be soaked by feed water 18-24 hours, then commissioning.

Ⅲ. System design

The designed steps of the UF system are shown below.



3.1 Raw water quality information

The design of the UF system requires customers' requirements and raw water quality information, like the types of raw water, turbidity, suspended solids, COD, PH, temperature, oil content, etc. Therefore according to customer's needs, company can select reasonable membrane products to achieve the best effect of water treatment.

3.2 Pre-process selection

In general, the customer's raw water quality cannot meet the requirements of the water penetration, so it needs Pre-treatment of the raw water in order to reach the requirements. The most widely used pre-treatment method of the UF system are clarification, sand filtration, medium filtering, disc filter and filter screen with between 50 to 100 m accuracy, and the filter accuracy is to be determined by the raw water quality.

3.3 Choice of filtration mode and flux of ultrafiltration membrane

The method of UF membrane filtration and the flux of operation directly affect the service life of the membrane. And if there are pilot data, the design flux should be based on the pilot data. The following table gives the selection of filtering methods and fluxes under normal circumstances. Special circumstances can also take special treatment, but it needs to be confirmed by the engineer.

Table 3 Flux selection of Anuket series

Design parameters		tap water	surface water			groundwater	return water		seawater	
Turbidity NTU		< 1	< 20	20<NTU<50	< 75	< 2	< 5	< 10	< 25	< 75
COD（mg/L）		< 2	< 2	<10	< 20	< 1	< 50	< 100	/	/
Design flux（L/m^2·h 25℃）		60～100	50～80	50～80	40～60	60～100	40～70	35～60	45~70	35~60
Rate of recovery（%）		90~95	90~95	90~95	85~90	90~95	80~90	80~90	90~95	90~95
Type	Cross flow	○	○	√	√	○	√	√	√	√
	Full flow	√	○	○	×	√	×	×	×	×
Air scrubbing		○	○	√	√	○	○	√	○	√
Online back washing dosing		○	○	√	√	○	√	√	√	√

Notes：1、√，Recommended use； ○，Can choose； ×，Not recommended for use；2、Suggestions above are based on the relevant experimental results and are for reference only.

3.4 Determination of water flux and recovery rate of ultrafiltration membrane

The water flux and recovery rate of the ultrafiltration membrane are a very important pair of indicators which characterizes its performance. Besides the effects of membrane itself, it must be taken into account the trans-membrane pressure, temperature, viscosity, particle concentration and so on subject to many factors still which could be estimated through Table 3. The water flux needed can be worked out based on the running temperature and temperature correction factor in Figure 3.

When it comes to ultrafiltration design, we should analyze specific issues case by case. And the reasonable scheme should be made depending on the features of the water quality.

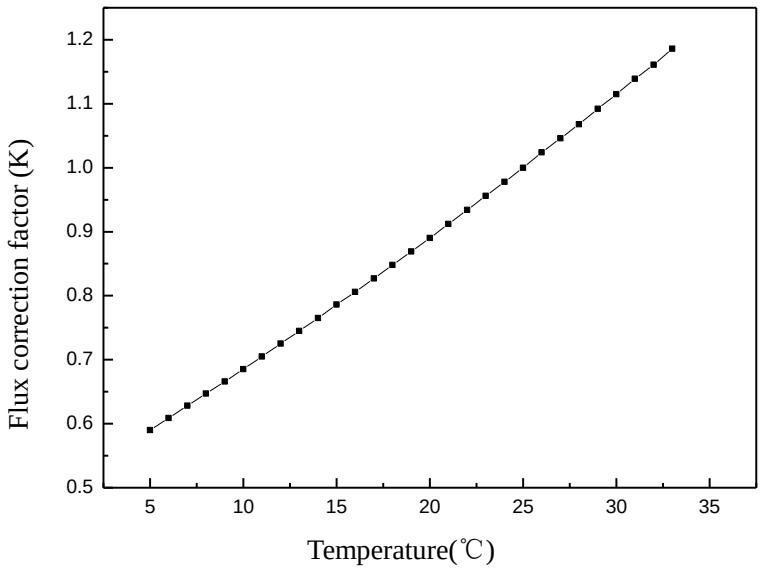


Figure 3. The Correction Factor of Flux Along with the Temperature Variation（25℃ defined as 1 ）

3.5 Determination of membrane area and number of membrane modules

The suitable subassembly of the ultrafiltration membrane in the series of Anuket products can be determined based on the water flux and filter type and the area based on the raw water quality and requirements of customers. In general case, the membrane area calculated multiply a design factor comes out the actual membrane needed. And the suitable subassembly of the membrane can be worked out based on the membrane area calculated and subassembly type.

3.6 Backwashing System Design

To make sure the longevity of the ultrafiltration system, the timing backwash of the subassembly is needed. The flow direction of the backwash and the production is on the contrary. This operation is unique to hollow fiber membrane subassembly which can reduce the water contamination efficiently. To avoid the contamination on the side of water production and the membrane hole blocking by impurities, the UF permeate water should be used as the backwash water.

1）Water flux: In general, as the backwash water yield is 2-3 times than the water production yield, the backwash flux of the membrane subassembly shoud be 6~8m^3/

h;

2）Lift: pipeline resistance needs taking into account. The pressure the backwash water into the ultrafiltration apparatus should be controlled between 0.1MPa～0.2MPa;

3）The material of pump should be the stainless steel.

3.7 Online Dosing Cleaning Apparatus Design

To suppress the growth of bacteria in the membrane subassembly, the dosing apparatus can be added alone. Three ways are available for dosing and based on the quality of the raw water, this apparatus can be used in superposition: The first way is the dosing process that 1～5ppm NaClO be mixed continuously into the inflow; The second way is the online dosing backwash process that 10～15ppm NaClO be mixed into the backwash water; The third way is the online dosing backwash and soak process that 50～500ppm NaClO be mixed into the backwash water during the system's period operation of 12-36 hours which is called dispersion cleaning. The equipment below are included in the sodium hypochlorite dosing apparatus:

1）Dosing tank: The storage capacity is by the standard of nycthemeron consuming. The dosing tank is equipped with the low liquid level switch, low liquid level alert and auto-stop metering pump;

2）Metering pump: The flux of the metering pump is determined by the standards of the concentration 10～15ppm of the sodium hypochlorite being mixed into the backwash water or the concentration 1～5ppm being mixed into the inflow. The pressure is greater than 0.3 MPa.

3.8 Chemical Cleaning Design

Under the same operating temperature, either the ultrafiltration trans-membrane pressure difference is rising 0.1MPa than the original or the flux is declining by 20%. And if the recovery cannot be reached perfectly through the backwash or dosing backwash, the chemical cleaning is needed.

The cleaning system includes the cleaning medicine tank, the cleaning pump and the cleaning filter. This process is manual and usually prescribed manually and necessary for operating after the halt of the cleaning apparatus.

（1）The Cleaning Medicine Tank

Using to prepare and store the cleaning fluid. Volume is determined by the follow factors: The amount of cleaning fluid of the single ultrafiltration apparatus subassembly calculated through the selected membrane subassembly' water volume amount in Table 1 and the consuming amount of cleaning fluid for the pipe and filter with appropriate allowance.

（2）The Cleaning Pump

1）Flux: Design the water flow meter according to the water flow by 1-1.5 times of each membrane subassembly and multiply the amount of single apparatus subassembly.

2）Lift: 0.2 MPa in general

3.9 Programmed step list of ultrafiltration device

Given that the ultrafiltration device needs to be backwashed every 30-60 minutes, it is automatically operating. The operation, cleaning parameters, steps and so on should be determined by the test in different occasions, because there is a huge difference in inlet water quality among different ultrafiltration systems. The principle is that when the water quality is bad, it should increase the frequency of backwash and chemically enhanced backwash.

The first attachment is the step list recommended by Anuket Ultrafiltration (it's related to the ultrafiltration technology process in the second attachment.)

p.s. The design above is mainly the common system. Anuket can design a special system to meet your specific needs.

Ⅳ.Integrity testing of ultrafiltration assemblies

4.1 Integrity Test Theory

Bubble point test is one of the most common and simple way to test the maximum pore size of the membrane whose purpose is to test the value of number when we deliver the air through a membrane full of liquid. Suppose the membrane can completely soak in the liquid medium, when the liquid wets the membrane, all the pores of the membrane will filled with liquid. If gas is applied to one side of the wetted membrane, with the pressure mounting, the gas, at first, won't go through the membrane because of its surface tension. At some point, the pressure becomes great enough to expel the water from one or more passageways establishing a path for the bulk flow of air. The pressure at which this steady stream is noticed is referred to as the bubble point.

This theory can be applied to measure the maximum pore size or to conduct the integrity test of the membrane and its unit in engineering. When the membrane is soaked (all the pores are filled with liquid), applying gas to one side of the membrane. When the air pressure is lower than the bubble point pressure, the pores of the membrane can stillbe wet. There is no obvious air flow could go through the wetted membrane pore, except a few air. But, if the membrane flawed (for example, fiber breakage), the air would be expelled from the flawed spots when the air pressure is far lower than the bubble point. By observing the bubbles from the side, which full of liquid, or by monitoring the changes of air pressure, the integrity of hollow fiber membranes and its units can be determined.

All of the Anuket technological units would go through the integrity test.

The ultrafiltration system needs to pass two integrity tests. One is the integrity of ultrafiltration units. The other is the integrity of matching pipe fittings, valves and the connecting components.

4.2 Integrity detection

In the ultrafiltration system, a transparent tube (transparent PVC or the PMMA tube) should be added to each end of the unit. The visible length of the tube is about

100mm.

Wet the membrane with the liquid. When all the pores in the membrane are filled with liquid, the oil-free compressed air should be slowly applied to one side of the membrane, and the air pressure should be increased to the range of 0.05-0.08MPa. At the same time, observing whether the transparent tubes of the side of water outlet has spilled out bubbles continuously (When the water outlet valve on.) If there are bubbles, the flawed membrane units can be detected.

The method of detecting the rupture of a single membrane unit is as follows. First, fill water into the hollow fiber to expel the air. Then, apply the purified air to the side of water outlet, and set the pressure at 0.05-0.08 MPa. Observe the end surface of membrane unit. If there are some large bubbles continuously expelled from the hollow fiber membrane, the membrane is ruptured. Then mark the ruptured spots, and detect the other side in the same way. At last, after drying the end surface, block the ruptured membrane by epoxy and blocking pins.

V. Chemical cleaning of Ultrafiltration module

5.1 Cleaning of Ultrafiltration module

After a period of operation, the ultrafiltration device will be affected by impurities and the performances of membrane will slightly decrease. When the membrane water output decreases by 20% or TMP increases by 0.1MPa, it's necessary to do the chemical recovery cleaning. Generally, the cleaning includes backwashing, fast flushing, online backwash dosing and chemical cleaning. It's to recover the flux of the membrane and keep its performance.

The Anuket ultrafiltration membrane modules' contamination consists of colloid, exceeded Fe or Mn in the water, non-organic pollutants caused by high concentration of suspended solids, organic pollutants caused by organic beings and pollutants caused by bacterial microorganisms. Therefore, it's necessary to figure out the reason and choose appropriate cleaning ways. The common cleaning agents are shown in the following table.

Table 4 common membrane contaminations and recovery cleaning agents

Pollutant type	Common pollutants	Chemical cleaning agents
Inorganic substance	Calcium carbonate, ferric salt and inorganic colloid	pH=2 Citric acid, hydrochloric acid or oxalic acid
	Difficult to dissolve inorganic salts such as barium sulfate and calcium sulfate	About 1% EDTA solution
Organic substance	Fats, humic acid, organic colloid	pH<11 sodium hydroxide solution
	Grease and other organic pollutants	0.1%～0.5% of sodium dodecyl sulfate、Triton X-100 etc.
	Protein, starch, oil and polysaccharides.	0.5%～1.5% protease, amylase
microorganism	Bacteria and viruses	About 1% of hydrogen peroxide or 50ppmsodium hypochlorite

5.2 Preparation of Anuket ultrafiltration membrane modules prior to cleaning

（1）**The selection of cleaning methods**

Choose appropriate cleaning agents according to the water quality and pollutant types.

Cleaning scheme（1）： Use acidic solution to clean the ultrafiltration devices.

This scheme is suitable for non-organic pollution in the inlet side of the membrane caused by Fe or Mn in the influent which exceeds the designed standards, or high concentration of suspended solids in the ultrafiltration membrane influent etc.

Cleaning scheme（2）： Use alkaline oxidant solution to clean the ultrafiltration devices.

When the organic substances are high in influent, the ultrafiltration membrane is easily polluted. And when the conditions are conducive to the survival of organisms, some bacteria and algae will also thrive in the ultrafiltration membrane modules, resulting in biological pollution.

（2）Matters needing attention in chemical cleaning

1）All cleaning agents must be put in the inlet side of the backing blowing

membrane modules in order to prevent impurities entering the inner surface of the membrane wall from the back of the integrally skinned filtration surface.

2）Fully backwashing with gas is necessary before the chemical cleaning of outer pressurized ultrafiltration devices.

3）It will take about 2 to 4 hours to finish the chemical cleaning of ultrafiltration devices.

4）If the shutdown time of the ultrafiltration devices is over three days after cleaning, the device must be maintained in accordance with the requirements of long time off.

5）The cleaning fluid must be made of ultrafiltration water or water of better quality.

6）The potential contaminants in cleaning agents must be removed before circulating in the membrane modules.

7）The temperature of cleaning liquid can be controlled at 10℃to 30℃ , and higher temperature of cleaning liquid can improve the efficiency of the cleaning.

8）When necessary, multi-cleaning agents can be used, but these cleaning agents and fungicides should not damage the membranes and component materials. Besides, cleaning agents should be fully discharged after cleaning, and the system should be cleaned by ultrafiltration or reverse osmosis water. Only after the cleaning can the cleaning agents be replaced.

（3）The cleaning system equipment

A cleaning solution tank, cleaning pump, and a cleanable filter (all of them can share the reverse osmosis cleaning system). A UPVC tube or hose can be used to connect the ultrafiltration device.

5.3 Typical Cleansing Scheme

The chemical cleansing process of ultrafiltration system is shown below:

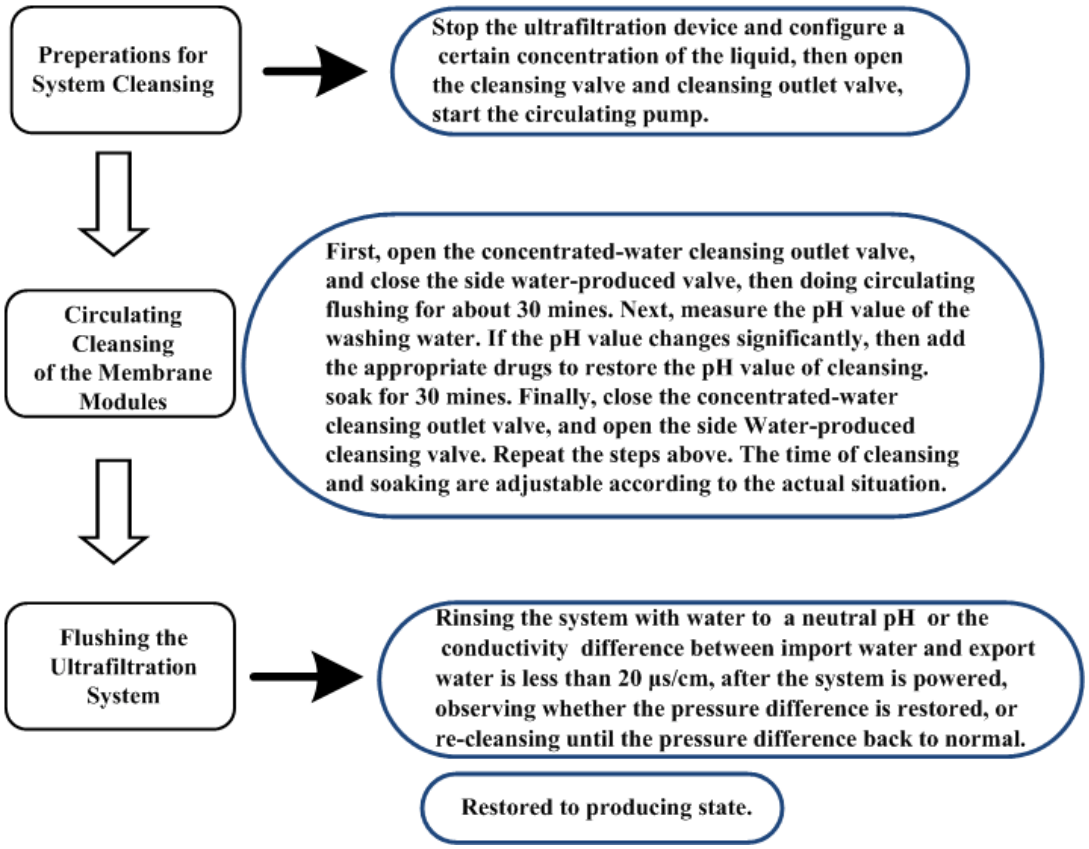


Figure 5.1 The Flowchart of the Typical Chemical Cleansing of Ultrafiltration System

Substantially, for the organic and inorganic pollution were produced at the same time, the chemical cleansing required two steps: first with acid wash, then lye wash. Note that the flushing of the system was required after each cleansing, and restored to producing state.

Three kinds of commonly used cleaning methods:

1. Acid Wash: 0.2%HCl or 2%Citric acid. This method is suitable for iron contamination and carbonate crystallization fouling.

2. Lye Wash: 0.1% NaOH + 200 ppm NaClO. This method is suitable for cleaning the pollution in ultrafiltration membrane which was caused by the organics and biological activities.

3. First with acid wash, then lye wash: first wash with 0.5%NaOH, then 0.2%HCl. This method is suitable for mixed pollution.

Notices:

1) Avoid direct contact with NaOH, NaClO and other such agents, for such agents having different degrees of corrosion, and NaClO is a strong oxidant.

2) Line pressure should be controlled when cleansing, so as to avoid excessive line pressure, which will lead to chemical splash.

3) When configure cleansing chemicals, the operator should wear full safety equipments to prevent contact with skin.

5.4 Shutdown Protection

Key points of the maintenance shutdown of the complete sets of membrane modules:

a) If the membrane modules on the device is shutdown in a short-term (2-3 days), it can run about 30 ~ 60min daily to prevent bacterial contamination;

b) If the membrane modules on the device is shutdown in a long-term (more than 7 days), the membrane must be fully cleaned, and then injected the protective liquid into the membrane modules, and check the pH of the protective liquid each month.

Attention: When saved, the ultrafiltration membrane modules must be filled with liquid or water at any time. Do not let it in dehydration. Once the membrane modules were in dehydration, the membrane flux will be decayed irreversibly and cannot be recovered again, thus the membrane modules were scrapped.

Ⅵ.Technical terminology relating to ultrafiltration

1. Anisotropic Membrane

It is a kind of synthetic polymeric hollow fiber, constituted by a layer of uniformly dense membrane outer Cylindrical surface which cuts off contaminants, and sponge-like inner structure which plays a supportive role.

2. Feed

Feed is the water that flows into ultrafiltration system.

3. Reject or concentration

It is a part of water cut off by ultrafiltration membrane in operation. It can be removed from the system or circulated in raw water tank.

4. Permeate

It is a part of water permeating membrane, free of colloid, particles and microbes.

5. Flux

The flow rate of water production through the membrane is usually expressed as the water output of per unit membrane area in per unit time, and the normal unit is L/㎡ h.

6. Trans-membrane Pressure TMP

It refers to the divergence between the pressure of permeate side and the average pressure of raw water out-in side, that is the difference of the average pressure between both sides of membrane.

$$TMF = \frac{\text{Inlet Pr}essure + Concentate\text{Pr}essure}{2} - \text{permeate pressure}$$

7. Forward wash/rinse

Ultrafiltration feed pump makes feed water flow through the washing valve at ultrafiltration inlet side, and be removed from the washing valve at concentrated water discharge side, to flush membrane contaminants and irrigate.

8. Backwash

It is opposite to filtrating direction, that is water equal or superior to filtrate water flowing towards inlet side from permeate side at hollow fiber membrane. Water flows through hollow fiber membrane in reversed direction so that membrane contaminants formed in filtration can be loosened and washed away.

9. Air Scrubbing

Let oil-free air flow through inlet surface at hollow fiber membrane, and then oscillate the mixture of air and water to loosen and discharge membrane contaminants.

10. Chemically Enhanced Backwash

Add chemicals with certain concentration and special effects in backwash water (commonly NaCIO).CEB is an operation to clean contaminants from the membrane surface.

11. Cleaning in place-CIP

When flux reduces to a certain extent, the device needs to be shut down for chemical cleaning. Chemical cleaning device includes cleaning tank, cleaning pump, and configured acid and alkali solution or fungicides. Chemicals enter into the ultrafiltration system through inlet side, and back to cleaning tank from the concentrated water side and permeate side, then circulate to clean contaminants effectively. And a soak sometimes follows.

12. Recovery

Recovery is the proportion of permeate water in total raw water, recovery% = permeate water/raw water×100.

13. Molecular weight cut off

The pore size of ultrafiltration membrane is usually defined by the molecular weight of its retentate. 90% of the molecular weight is called molecular weight cutoff. Usually, it is determined in accordance with typical spherical molecular whose molecular weight is known, such as glucose, sucrose, bacitracin, myoglobin, pepsin, globulin, etc..

14. Concentration polarization

It is aggregation phenomenon where retained suspended solids aggregate on the membrane surface. The improvement of liquid tangential velocity on fiber membrane surface can decrease concentration polarization effectively.

15. Membrane fouling

Fouling is a phenomenon where macromolecular solutes (like particulates, colloidal particles, organisms and microbes, etc.) in processed liquid produce physical and chemical or mechanical reaction with membrane so that they absorb and precipitate on the membrane surface or inside membrane pore to minimize or block membrane pore, resulting in the decrease of membrane water permeability and separation capacity.

Ⅶ. Operation record of ultrafiltration system

Date			Recorder	

	COD（mg/L）	Turbidity	SDI	pH
Raw water				
yielding water				

Recording time	Water inlet temperature（℃）	Water inlet pressure（MPa）	Concentrated water pressure（MPa）	Outlet pressure（MPa）	Outlet flow（m^3/h）	Concentrated water outlet flow（m^3/h）
0：00						
1：00						
2：00						
3：00						
4：00						
5：00						
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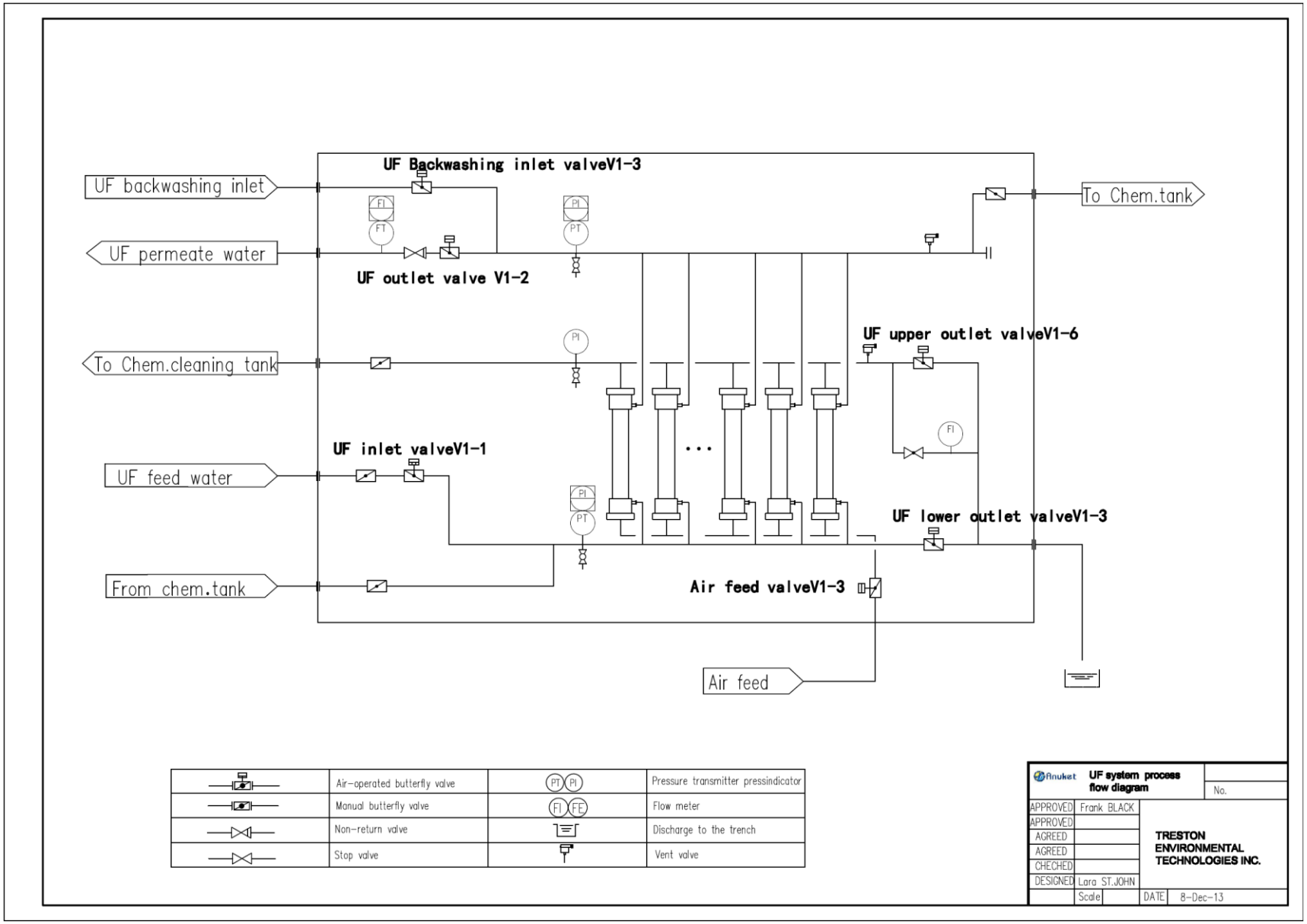
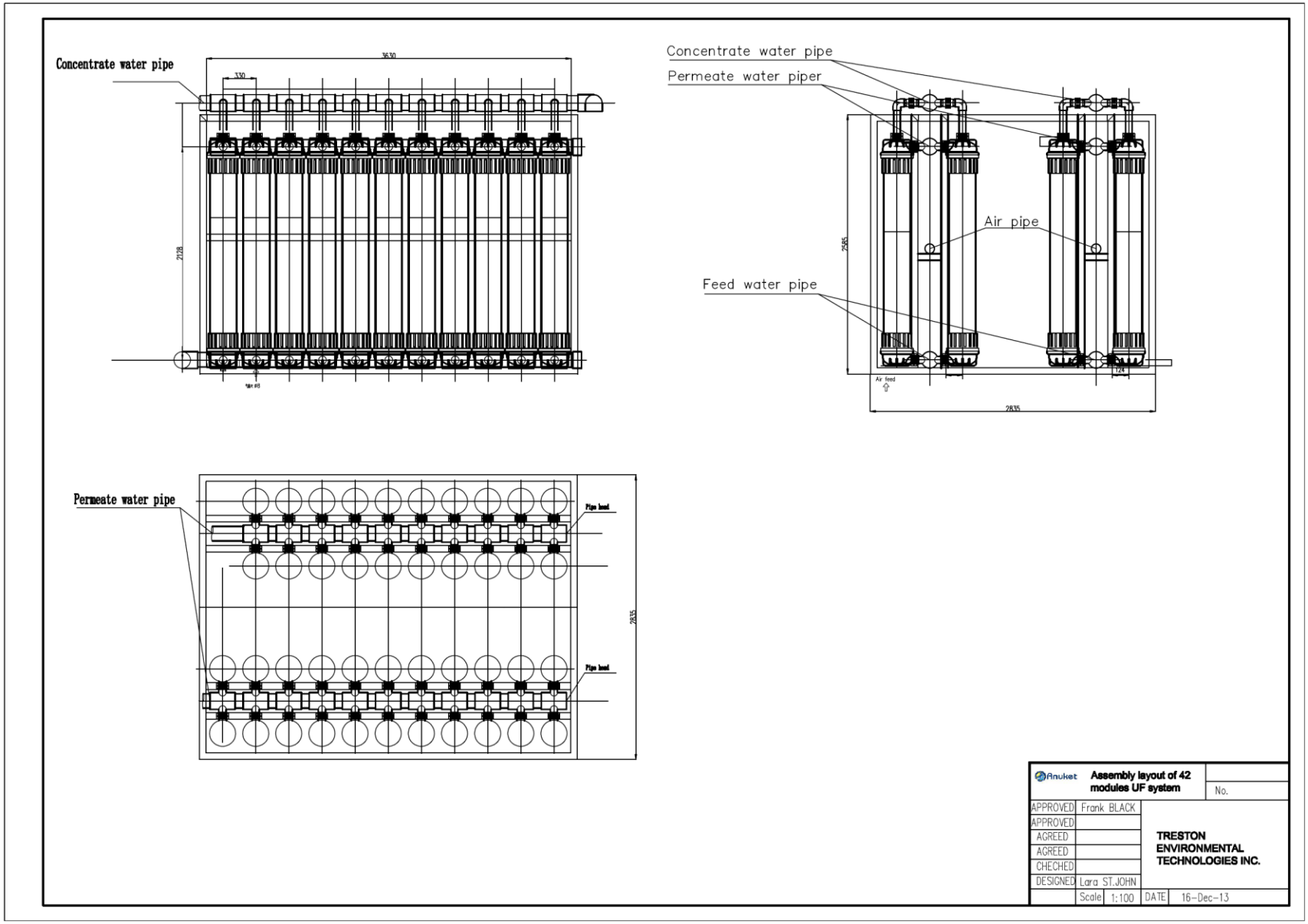
Annex I Table of p rogram control steps for Anuket ultrafiltration device

Condition						
Steps	Serial nembers	1	2	3	4	5
	steps	Forward wash	run	Up backwash	Air scrubbing	Downbackwash
Pump condition	UF feed water pump (Variable Frequency operation)	V.F. running	V.F. running	V.F. running	V.F. running	V.F. running
	Backwashing pump	0	0	1	0	1
	Backwashing oxidizing agent dosing pump	0	0	1	0	1
	Online chemical cleaning acid dosing pump	0	0	0	0	0
	Online chemical clean oxidizing agent dosing pump	0	0	0	0	0
Valve condition	V1-1inlet valve	1	1	0	0	0
	V1-2outlet valve	0	1	0	0	0
	V1-3bachwashing inlet valve	0	0	1	0	1
	V1-4intake valve	0	0	1	1	0
	V1-5backwashing lower drain valve	0	0	0	0	1
	V1-6backwashing upper water outlet valve	1	0	1	1	0
Run time		20～60S	30～60min	20～60S	20～60S	20～60S
	1、1 stands for open/start of those pump/valve while 0 for stop； 2、The order of running steps：1→2→3→4→5→1					

Annex Ⅱ Flow chart of Anuet Ultrafilitration system



Annex III Anuket ultrafiltration assembly



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