Dow Water & Process Solutions

IntegraPac™ Module and Skid Product Manual

Version 1

May 2013

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DOW™ IntegraPac™ Ultrafiltration Module and Skid Product Manual

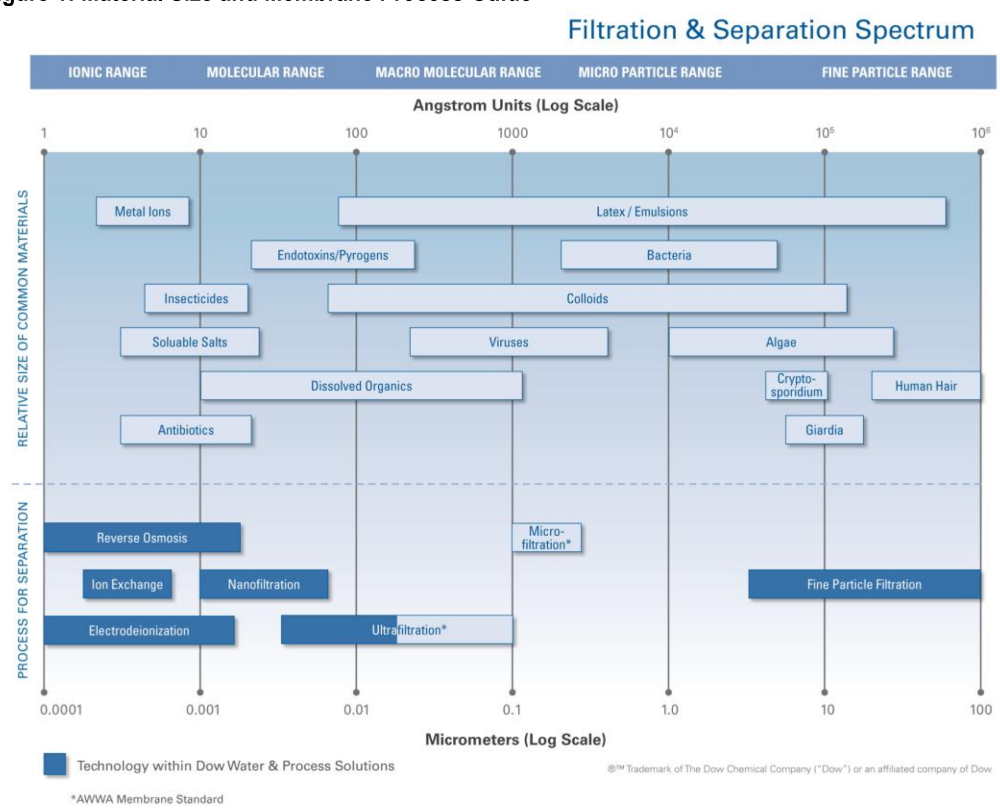
1. Introduction

Ultrafiltration (UF) involves pressure-driven separation of materials from a feed solution. The technology achieves separation through sieving and is used to remove particulate and microbial contaminants, but does not remove ions or molecules of low molecular weight. The process typically operates with a feed pressure of 4 to 100 psig (0.28 to 6.9 bar). UF plants are automated and have low operational labor requirements. Depending on the feed water quality, these systems can require frequent cleaning. UF membranes generally may have a service life of five years or longer, depending on system operations. UF technology is commercially available in tubular, hollow-fiber, plate and frame, flat sheet, and spiral wound configurations.

UF membranes reject solutes ranging in size from 0.005 microns and larger. Figure 1 provides a guide to the relationship between common material sizes, separation processes, and pore size measurements. The UF membrane process separates molecules in solution on the basis of size. The pore size and molecular weight cut-off (MWCO) are often used to characterize a membrane. The pore size is the nominal diameter of the openings or micropores in the membrane expressed in micron (micron meters μm). The MWCO is the molecular mass or weight of a solute that rejects greater than 90 percent. The unit of measurement for MWCO is the Dalton (D).

Different membrane materials with the same nominal MWCO may have differing solute rejection. Pore size distribution and uniformity rather than the chemical nature of the membrane material may cause this effect. Because factors other than pore size or MWCO affect the performance of membranes, challenge studies are used to demonstrate membrane performance and benchmark different membranes.

Figure 1: Material Size and Membrane Process Guide



The DOW Ultrafiltration hollow fiber membrane shown in Figure 2 is 1.3 mm outside diameter and 0.7 mm inside diameter and is made from PVDF polymer. The fibers are strong because of a combination of the polymer type, the wall thickness, high porosity sub structure, and smaller pores at the surface of the fiber. The PVDF membranes offer high chemical resistance and are tolerant to temperatures ranging from 1 to 40ºC.

The 0.03 µm nominal pore size combines high filtration performance and high flux. The smaller pore size provides stabile long term filtration performance compared to microfiltration hollow fiber membranes.

Dow has taken its Ultrafiltration technology to a new product format, referred to as IntegraPac™ modules and skids. This range includes interconnecting end caps that reduce skid capital costs and engineering design efforts.

2. Description of DOW™ Ultrafiltration IntegraPac™ Module

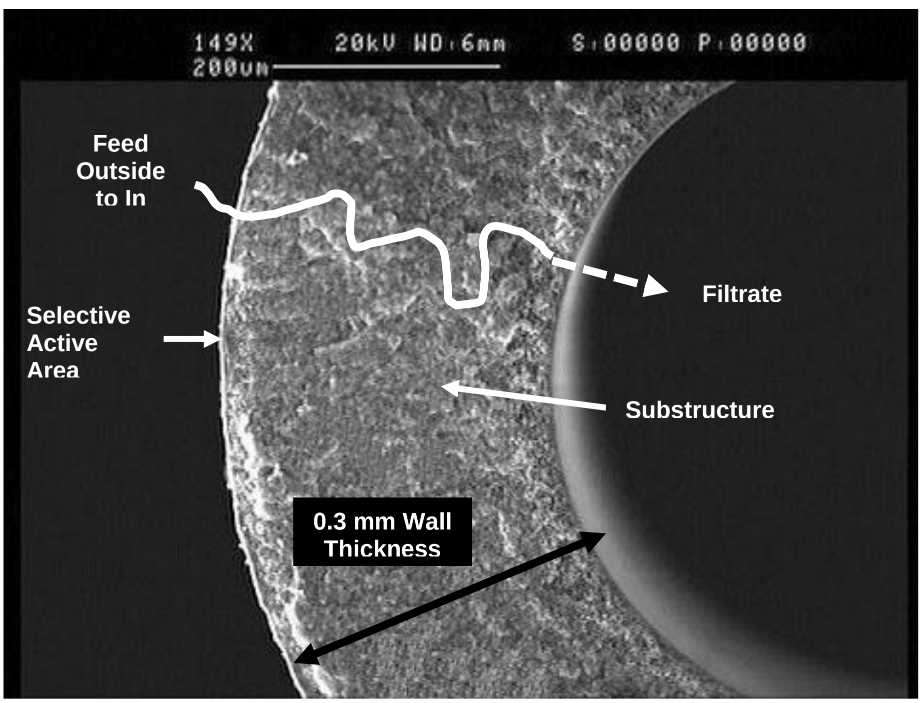
2.1 IntegraPac™ Module Features

The DOW Ultrafiltration IntegraPac™ modules are made from high strength, hollow fiber membranes and are engineered to reduce design and fabrication requirements with features and benefits including:

- 0.03 µm pore size for removal of bacteria, viruses, and particulates, a 6 log removal of bacteria, a 2.5 log removal on viruses and a <2.5 SDI guarantee with proper operation
- PVDF fibers which offer strength, chemical and fouling resistance which allows for extended membrane life and consistent long term performance
- Outside-In flow configuration which allows higher TSS feed waters, while maintaining reliable system performance and producing high quality filtrate

Innovative end-cap design enables direct coupling of modules reducing the need for piping and manifolds. The outside-in flow configuration allows the use of highly effective air scour cleaning which enhances particle removal and improves recovery. A dead-end flow format achieves higher recovery and energy savings. The module housing design eliminates the need for separate pressure vessels while the vertical orientation allows easy removal of air from cleaning and integrity testing processes.

Figure 2: Wall Cross Section of the Hollow Fiber



The IntegraPac™ module is shown in Figure 3. There are six connections on each module. The top end cap includes 4"DN 100 concentrate ports and an 1½" DN 40 union for the. The bottom end cap includes 4" DN 100 feed ports and a 3/8" air inlet connection on the side allowing for easy access. Included with the module are the couplers, air fitting, and transparent filtrate elbow. The IntegraPac™ skid offering is shown in Figure 4.

Figure 3: IntegraPac™ Module

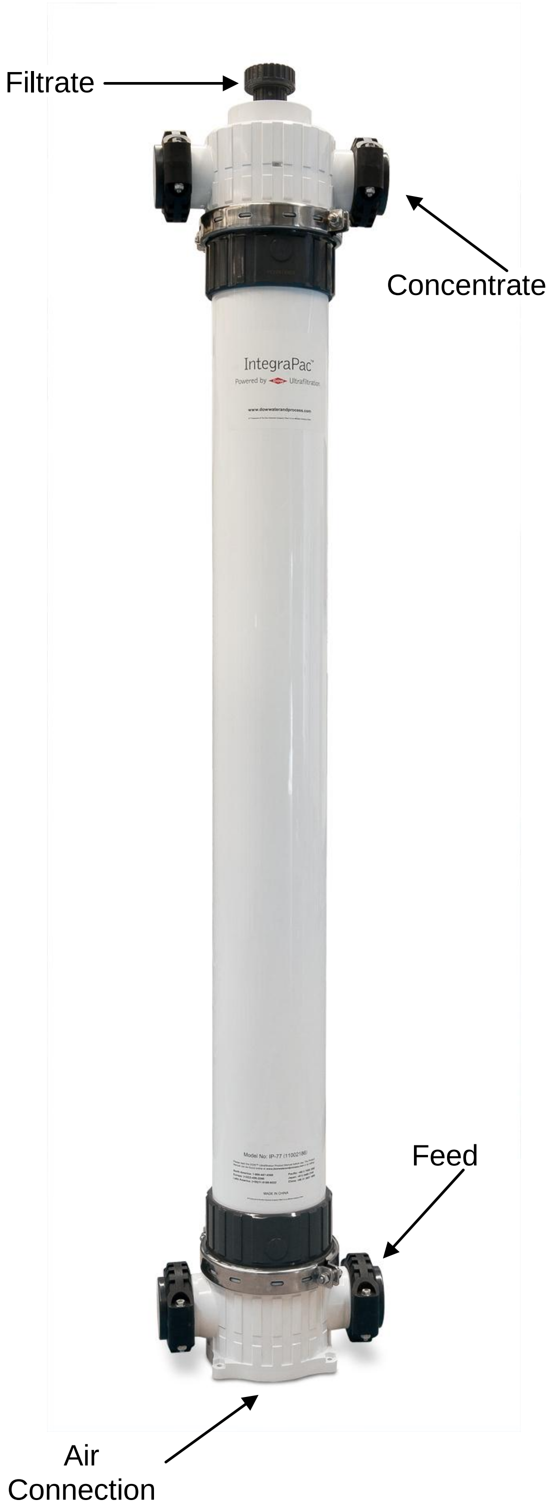
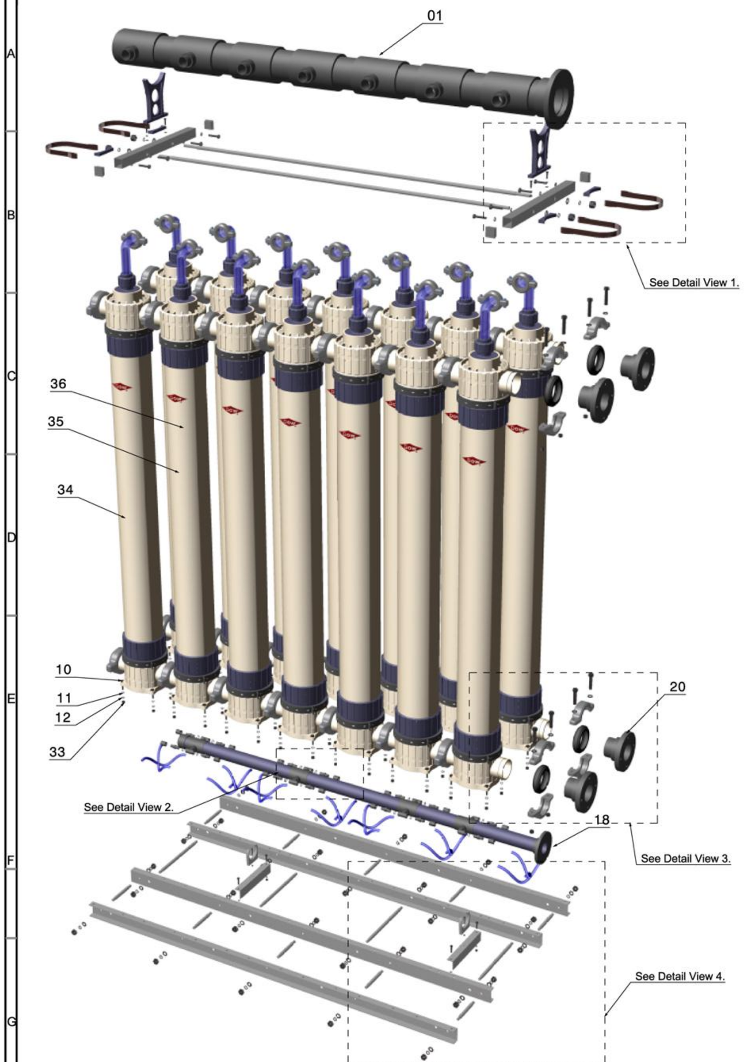
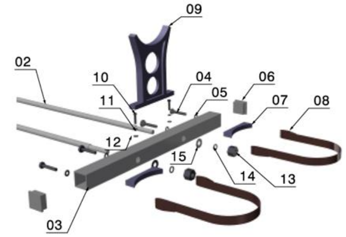
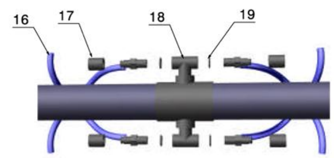


Figure 4: IntegraPac™ Skid Components

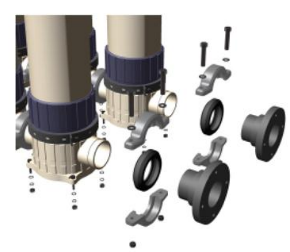




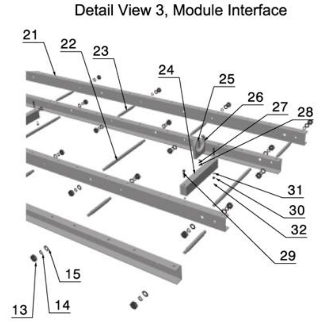
Detail View 1, Top Frame



Detail View 2, Air Scout Pipe



Detail View 3, Module Interface



Detail View 4, Bottom Frame

Installation Instructions:

1, Assemble the bottom frame.
2, Install the air pipe(18) on the bottom frame, between the two rows of modules.
3, Drain preservative from modules. Replace the threaded plug with quick tube connector (17) to the bottom end cap. All the removed port plugs and threaded plugs need to be retained for future use.
4, Mount modules one by one to the bottom frame using appropriate hoist. Put bolts (10/11/12/33) on the bottom end cap without fastening. The IP-XXL(34) and IP-XXR (35)modules should be placed at the "far" end of the skid.
5, After each module is mounted, connect air tubes via quick connector (17) to the bottom end cap.
6, Use the 4" coupling to connect modules. Do not tighten the bolts on the couplings until all modules are installed.
7, Install the top frame and filtrate pipe supports(9) on the top end caps.
8, Tighten all bolts on the bottom end caps and the couplings between modules to torque of 12 to 15 N*m.
9, Install the filtrate pipe (1)on the top of the skid.
10,Use the union nut to connect the transparent 90ºelbow assembly to the top end cap. Use the 2" coupling to connect the transparent 90ºelbow assembly to the filtrate pipe(1). The bolts of couplings should be tightened to torque of 5 to 8 N*m.
11, Connect the two modules on the "near" end of the skid to the main feed and concentrate pipes (provided by customer).
12, Connect the air pipe(18) and filtrate pipes(1) to main pipes (provided by customer) according to the detail skid drawing.

No.	Part No.	Name & Specification	Material
36	10410040/10410645	IP-77/IP-51	Assembly
35	10409997/10410662	IP-77R/IP-51R	Assembly
34	10410164/10410661	IP-77L/IP-51L	Assembly
33	10410957	Nut M10	SS200/Dacro
32	10410960	Nut M8	SS200/Dacro
31	10410954	Spring Gasket M8	SS316
30	10410951	Flat Gasket M8	SS316
29	10410928	Bolt M8X25	SS316L
28	10410956	Nut M5	SS200/Dacro
27	10410930	Flat Gasket M5	SS316
26	10383583	PIPE Carrier Φ75	UPVC
25	10410929	Bolt M5X40	SS316L
24	10410885	Angle Steel 40X40X4 L=340	Assembly
23	10410885	Round Steel Φ20 L=410	Assembly
22	10410885	Round Steel Φ20 L=194	Assembly
21	10410885	8# Channel Steel	Assembly
20	10410555	Grooved Flange Connector	UPVC
19	10385958	Composite O-Ring	EPDM
18	10410554	Air Scour Pipe	UPVC
17	10410926	Quick Tube Connector	ABS
16	10382003	Hose 3/8"	PE
15	10410952	Flat Gasket M16	SS316
14	10410955	Spring Gasket M16	SS316
13	10410958	Nut M16	SS200/Dacro
12	10410959	Spring Gasket M10	SS316
11	10410953	Flat Gasket M10	SS316
10	10410946	Bolt M10X40	SS316L
09	10410145	Filtrate Pipe Support	UPVC
08	10393962	Pipe Clamp L=400	SS316
07	10381101	Saddle t10-6"	PP
06	10410894	Sealing Head	ABS
05	10410951	Flat Gasket M8	SS316
04	10410927	Bolt M8X80	SS316L
03	10410884	Square Hollow Steell 50X50X4	Assembly
02	10410884	Round Steel φ20	Assembly
01	1010553	Filtrate Pipe	UPVC

Bill of Material

DOW
Ultrafiltration

FILE NAME: IP77/51-05

REFERENCE

REV	APPRD. BY	DATE	DESCRIPTION

TECHNOLOGY PROVIDER:
DOW Water & Process Solutions
System Engineering
688 Chuangye Avenue, Huzhou
Tel: +86-572-2668888

CUSTOMER:
GENERAL

PROJECT TITLE :
Dow IntegraPac™ Skid

DRAWING TITLE :
IP77/51
SYSTEM DRAWING

SCALE : N.T.S.
APPROVED BY B.He
CHECKED BY JH.Xu
DESIGNED BY T.Chen
DRAWN BY J.Cai
DRAWING NO. : IP77/51-05 | SHEET NO. 1 | REV. NO. 1

Notes:

1, UF Module should be kept preserved, as shipped from factory, until ready for operation. If leakage occurs, refer to DOW Ultrafiltration Technical Manual for procedure to replace preservative.
2, Fasten the bottom frame to the even ground or foundation with expansion bolts before installing modules and putting skid into operation.
3, Upstream process pipework should be thoroughly flushed prior to installation and commissioning.
4, Preservative consists primarily of Sodium Metabisulfite (about 1% solution).
5, All pipes, which connect with skid, should be firmly supported and fixed, make sure these pipes will not influence the stability of the skid when operating.

Feed flow enters and is distributed into the modules through the side feed ports located on the bottom end cap. Feed flow enters the module on the outside of the fiber. The air connection is located on the side of the bottom end cap and is used for air scouring and integrity testing. The concentrate (discharge of waste flows from the outside of fiber) and filtrate ports (inside of fiber) are located on the top cap.

Table 1: IntegraPac™ Module and Skid Connections

IntegraPac	Feed & Concentrate	Filtrate	Air
Module	DN 100 (4 inch) Coupler	DN 40 (1.5 inch) Threaded Union	3/8 inch Threaded (G3/8")
Skid	DN 100 (4 inch) Flange	DN 150 (6 inch) Flange	DN 65 (2.5inch) Flange

Table 1 shows the type and size of the connections for the IntegraPac™ modules.

2.2 IntegraPac™ Module and Skid Specifications

Table 2 shows dimensions and specifications for the IntegraPac™ modules as depicted in Figure 5. Table 3 includes the dimensions and specifications for the IntegraPac™ skids as depicted in Figure 6. Note that manufacturing and thermal expansion tolerances are not included in the dimensions below. Refer to the installation drawings for this information.

Table 2: IntegraPac™ Module Dimensions and Specifications

Module Properties	IntegraPac IP 51		IntegraPac IP 77	
	SI	US	SI	US
Length - L	1988 mm	78.28"	2488 mm	97.95"
Length - L1	1500 mm	59.1"	2000 mm	78.7"
Length - L2	1689 mm	66.5"	2189 mm	86.2"
Length - L3	1864 mm	73.4"	2364 mm	91.3"
Diameter - D	225 mm	8.9"	225 mm	8.9"
Width – W1	360 mm	14.2"	360 mm	14.2"
Width – W2	342 mm	13.5"	342 mm	13.5"
Surface Area	51 m2	549 ft^2	77 m2	829 ft^2
Volume per Module	49 L	13 gal	53 L	14 gal
Weight (water filled)	102 kg	225 lbs	119 kg	262 lbs
Shipping Weight (w/o packaging)	53 kg	117 lbs	66 kg	146 lbs
Housing	UPVC		UPVC	

Figure 5: IntegraPac™ IP 51 and IP 77 Module Reference Drawing

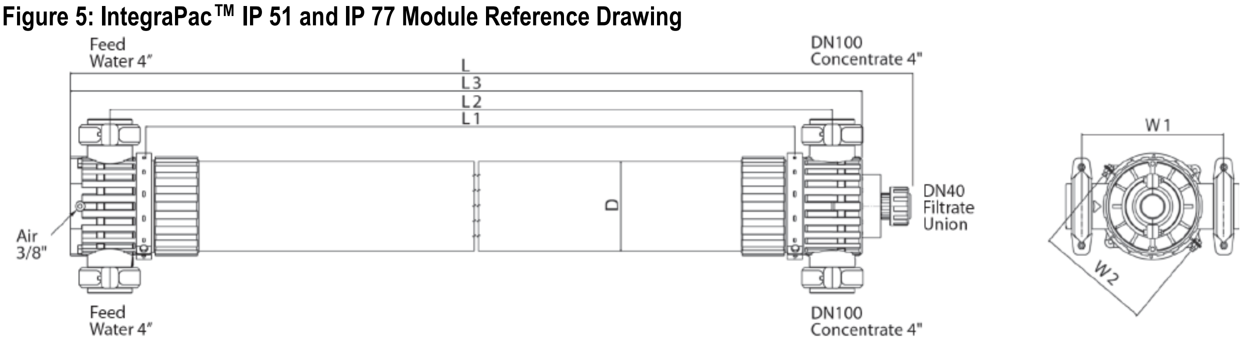


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Table 3: IntegraPac IP-51 and IP-77 Skid Details

Skid Configurations with IP-77 Modules																	
Number of modules	IntegraPac Skid	Total Membrane Area		Flow @ 65 lmh (38 gfd)		Length (L)		Width		Height (H)		Weight, dry (incl. modules)		Weight, filled (incl. modules)		Hold-Up Volume	
		m^2	ft^2	m^3/hr	gpm	mm	ft.	mm	ft.	mm	ft.	kg	lbs.	kg	lbs.	m^3	US gal
6	IP-77-06	462	4,974	30	132	1,241	4.1	764	2.51	2,875	9.43	496	1,093	840	1,852	0.32	84.0
8	IP-77-08	616	6,632	40	176	1,604	5.3	764	2.51	2,875	9.43	644	1,420	1,102	2,429	0.42	112.0
10	IP-77-10	770	8,290	50	220	1,967	6.5	764	2.51	2,875	9.43	791	1,744	1,364	3,007	0.53	140.0
12	IP-77-12	924	9,948	60	264	2,330	7.6	764	2.51	2,875	9.43	939	2,070	1,626	3,585	0.64	168.0
14	IP-77-14	1,078	11,606	70	309	2,693	8.8	764	2.51	2,875	9.43	1,091	2,405	1,893	4,173	0.74	196.0
16	IP-77-16	1,232	13,264	80	353	3,056	10.0	764	2.51	2,875	9.43	1,249	2,754	2,165	4,773	0.85	224.0
18	IP-77-18	1,386	14,922	90	397	3,419	11.2	764	2.51	2,875	9.43	1,401	3,089	2,432	5,362	0.95	252.0
20	IP-77-20	1,540	16,580	100	441	3,782	12.4	764	2.51	2,875	9.43	1,554	3,426	2,699	5,950	1.06	280.0
22	IP-77-22	1,694	18,238	110	485	4,145	13.6	764	2.51	2,875	9.43	1,706	3,761	2,966	6,539	1.17	308.0

Skid Configurations with IP-51 Modules																	
Number of modules	IntegraPac Skid	Total Membrane Area		Flow @ 65 lmh (38 gfd)		Length (L)		Width		Height (H)		Weight, dry (incl. modules)		Weight, filled (incl. modules)		Hold-Up Volume	
		m^2	ft^2	m^3/hr	gpm	mm	ft.	mm	ft.	mm	ft.	kg	lbs.	kg	lbs.	m^3	US gal
6	IP-51-06	306	3,294	20	88	1,241	4.1	764	2.51	2,375	7.79	418	922	738	1,627	0.29	77.7
8	IP-51-08	408	4,392	27	117	1,604	5.3	764	2.51	2,375	7.79	540	1,190	966	2,130	0.39	103.6
10	IP-51-10	510	5,490	33	146	1,967	6.5	764	2.51	2,375	7.79	661	1,457	1,194	2,632	0.49	129.4
12	IP-51-12	612	6,588	40	175	2,330	7.6	764	2.51	2,375	7.79	783	1,726	1,422	3,135	0.59	155.3
14	IP-51-14	714	7,686	46	204	2,693	8.8	764	2.51	2,375	7.79	909	2,004	1,655	3,649	0.69	181.2
16	IP-51-16	816	8,784	53	234	3,056	10.0	764	2.51	2,375	7.79	1041	2,295	1,893	4,173	0.78	207.1
18	IP-51-18	918	9,882	60	263	3,419	11.2	764	2.51	2,375	7.79	1167	2,573	2,126	4,687	0.88	233.0
20	IP-51-20	1,020	10,980	66	292	3,782	12.4	764	2.51	2,375	7.79	1294	2,853	2,359	5,201	0.98	258.9
22	IP-51-22	1,122	12,078	73	321	4,145	13.6	764	2.51	2,375	7.79	1420	3,131	2,592	5,714	1.08	284.8

IP-XX-XX

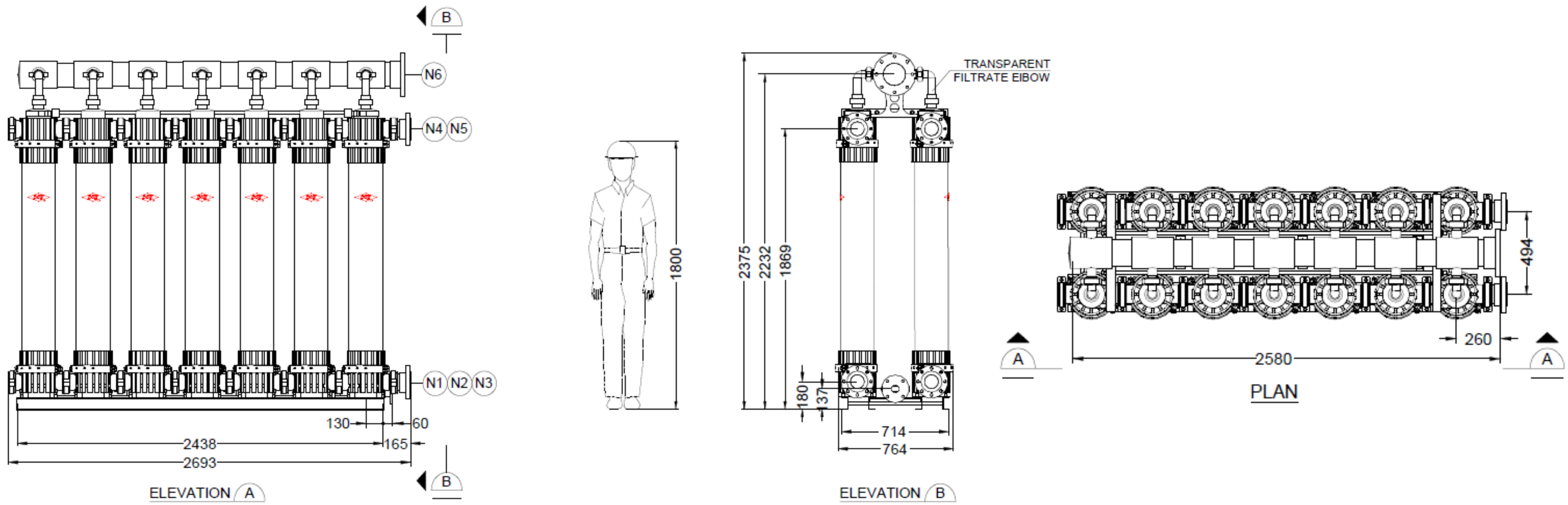
No. of IntegraPac™ modules in a skid

Membrane area of an IntegraPac™ module

IntegraPac™ shortform

Figure 6: IntegraPac™ Skid Reference for Dimensions

Example: 2x7
IntegraPac IP-51-14 Arrangement

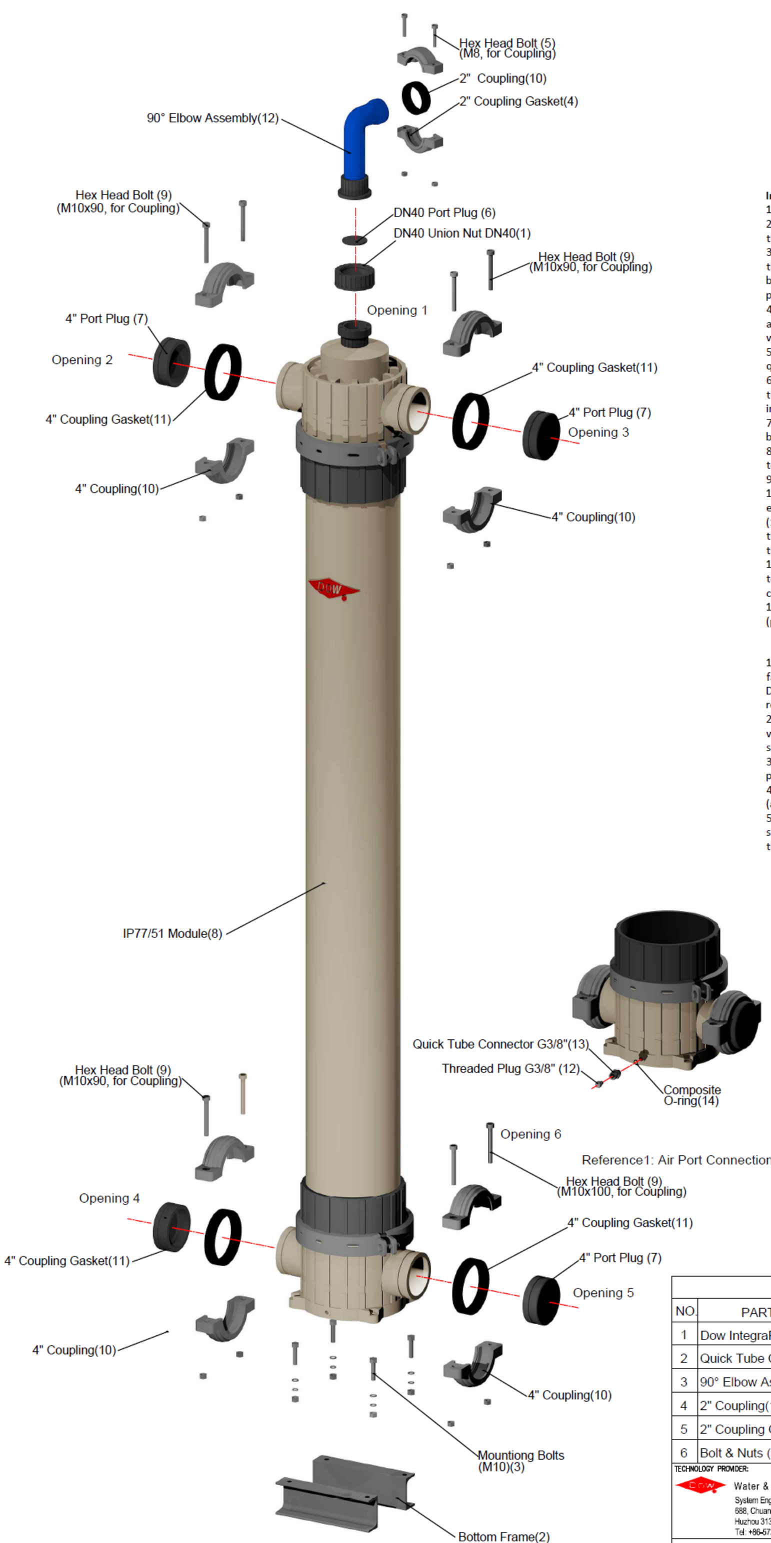


2.3 Installation

Detailed installation instructions are provided for the Dow IntegraPac™ skids upon request.

Figure 7 provides the installation details for DOW™ IntegraPac™ modules.

Figure 7: Installation™ Drawing for IntegraPac™ IP 51 and IP 77 Modules



Installation Instructions:

1、Assemble the bottom frame (2).
2、Install the air header on the bottom frame (2), between the two rows of modules or by custom design.
3、Drain Storage solution from modules . Replace the threaded plug (12) with quick tube connector (13) to the bottom end cap. All the removed port plugs (7) and threaded plugs (12) need to be retained for future use.
4、Mount modules one by one to the bottom frame (2) using appropriate lifting device. Put bolts (3) on the bottom end cap without fastening.
5、After each module is mounted, connect air hoses using quick connector (13) to the bottom end cap.
6、Use the 4" coupling (10) to connect modules. Do not tighten the bolts (9) on the couplings until all modules are installed.
7、Tighten all bolts on the bottom end caps and 4" couplings between modules to torque of 12 to 15 N*m.
8、Install the top frame and filtrate header supports on the top end caps.
9、Install the filtrate pipe on the top of the skid.
10、Use the union nut (1) to connect the transparent 90° elbow assembly (12) to the top end cap. Use the 2" coupling (10) to connect the transparent 90° elbow assembly (12) to the filtrate header. The bolts of 2" couplings should be tightened to torque of 5 to 8 N*m.
11、Connect the two modules on the "near" end of the skid to the main feed and concentrate pipes (provided by customer).
12、Connect the air and filtrate headers to main pipes (provided by customer) according to the pipe layout drawing.

Notes:

1、UF Module should be kept preserved, as shipped from factory, until ready for operation. If leakage occurs, refer to DOW Ultrafiltration Product Manual for procedure to replace storage solution.
2、Fasten the bottom frame to the even ground or foundation with expansion bolts before installing modules and putting skid into operation.
3、Upstream process pipework should be thoroughly flushed prior to installation and commissioning.
4、Storage solution consists primarily of Sodium Metabisulfite (about 1% solution).
5、All pipes, which connect with skid, should be firmly supported and fixed, make sure these pipes will not influence the stability of the skid when operating.

PACKING LIST

NO.	PART NAME	QTY.	MATERIAL CODE	GMID
1	Dow IntegraPac™ Module(8)	1	IP-77/51	10410040/10410645
2	Quick Tube Connector(13)	1	—	10410926
3	90° Elbow Assembly (12)	1	IP.09	10409998
4	2" Coupling(10)	1	SFP28-021A	10385944
5	2" Coupling Gasket(4)	1	SFP28-022(A-2)	10385964
6	Bolt & Nuts (5)	2	—	10385968

TECHNOLOGY PROVIDER:
Water & Process Solutions
System Engineering
688, Chuangye Avenue
Huzhou 313000, P.R.C
Tel: +86-572-2668888

PROJECT TITLE : Dow IntegraPac™ Module

DRAWING TITLE : IP77/51Module Installing Drawing

SCALE :	1:30
APPROVED BY	B.He
CHECKED BY	JH.Xu
DESIGNED BY	CC.Gao
DRAWN BY	CC.Gao
DRAWING NO. :	IP77/51-04

REV	APPRD. BY	DATE	DESCRIPTION

3. Shipping and Storage

To control bacterial growth and prevent damage caused by fibers drying out, the DOW™ Ultrafiltration IntegraPac™ modules are wetted and stored in a non-hazardous standard storage solution containing pH buffered food-grade 1% wt. sodium metabisulfite (SMBS). At the end of the manufacturing process, storage solution is automatically injected into the modules and all inlet and outlet ports are sealed using plastic discs, couplings, and threaded plugs. If the modules will be exposed to low temperatures, glycerin can be added to the storage solution to prevent freezing. The modules are sealed in a plastic bag prior to boxing. Depending on the total number of modules and method of shipping, the modules are either shipped on pallets as shown in Figure 8 below or in crates. Skid components (underframe, air scour piping, filtrate piping) are shipped in a separate boxes or crates.

As part of the quality assurance program, all DOW™ IntegraPac™ modules are tested for integrity and performance ("wet tested") at the factory, prior to packaging and shipment.

Storage solution is automatically delivered into the module housings prior to sealing of the module ports. The target volume of storage solution used for each module is 4L (1 gal) for IP-51; and 6L (1.6 gal) for IP-77. After adding storage solution and sealing the openings, the modules are enclosed in plastic bags prior to boxing for dust protection. The storage solution volume and complete sealing of the module ports and openings help ensure a stable solution environment during transportation and storage of new modules.

The bagged modules are stored in cardboard boxes, with one module per box. Saddle-shaped cushion inserts are located at both ends of the box and along the module to support and protect the modules from damage during shipping and handling. Depending on the total number of modules and required shipping method, the boxed modules are either palleted or crated for transportation. Other skid parts are placed in crates and shipped with the modules.

Mechanical damage to module housing, membrane, and connections may result if the module, boxed module, pallet or crate is dropped, and otherwise mishandled. The modules should be handled with care, with particular attention during transportation.

Figure 8: Pallet of IntegraPac™ Modules for Shipping

Storage of New IntegraPac™ Modules:

Modules are recommended to be shipped and stored in their original packaging separate from the system racks, and loaded into the system just prior to start-up. There may be cases where the customer prefers to pre-install the modules on the system racks; for example, to allow factory acceptance testing of packaged or mobile systems prior to shipping, or work scheduling at site to eliminate the separate step for module loading.

These guidelines should be followed for storage of new DOW™ IntegraPac™ modules:

- Keep modules in original factory packaging.
- To minimize the potential for leakage of storage solution, modules should be stored in horizontal position.
- To prevent collapse of the boxed modules, limit vertical stacking to four layers of modules.
- Store inside a cool and dry building or warehouse, away from sources of heat, ignition, and direct sunlight. An ambient temperature of 20°C (68 ºF) to 35°C (95 ºF) is recommended for ideal storage conditions.
- Temperature limits for modules during shipping and storage is 1ºC (33.8 ºF) to 40ºC (104 ºF). Modules must be protected from freezing or excessive heat during shipping and storage. In order to avoid abrupt variations in temperature; equalization should be allowed to occur at a maximum temperature differential of +/- 1°C (1.8 ºF) per minute. If freezing conditions are anticipated during the customer's shipping and storage of modules, please notify DW&PS at the time of order placement. Glycerine may be added to the storage solution at the factory prior to shipping to allow for shipment and storage at freezing conditions.
- Sealed modules may be stored up to 1 year from date of manufacture, at the recommended storage conditions described above and in the original packaging.

Storage of modules installed on a skid:

Modules (hollow fibers) installed during assembly of a skid should not be allowed to dry out. Dry membrane fibers will irreversibly lose flux. Blank or "dummy" modules are available to accurately build and assemble a skid. Consult the manufacturer regarding modules installed on a skid and not planned for operations within 7 days.

UF systems are designed to run continuously and membrane systems perform better when operated continuously. However, in reality UF systems will start-up and shutdown on some frequency. Before the UF system shuts down, the system must be cleaned using air-scour and filtrate water backwash to prevent bio-growth in the UF system.

The water used for backwash before shutdown should not contain chemicals. Any feed water and backwash chemical dosing used should be stopped before the last cleaning and shutdown. After cleaning, all valves on the UF system should be closed to seal the system.

To avoid leakage in the module housing end caps and clamps, the backpressure in the modules should be controlled when the UF system shuts down, especially in case of non-scheduled shutdowns, e.g. power failure or emergency shutdowns.

When the system is down for greater than 96 hours, note the following:

- The module should not dry out. Dry membrane fibers will irreversibly lose flux at any time.
- The system should be adequately protected against bio-growth, flushed for duration of 30 to 60 minutes once a day, or operated every 24 hours. If flushing with feed water, the quality should be <10 NTU or <10 mg/L TSS.
- The system should be protected against temperature extremes. The UF system can be shut down for 96 hours without adding storage solution or taking additional precautions for microbiological fouling.

Storage of modules off skid:

For cases of long-term shutdown where the modules will remain out- of-service for an extensive period of time (weeks to months), the modules can be removed from the skid and stored to eliminate maintenance operations. If the module has been in service, a Chemically Enhanced Backwash (CEB) or Clean In Place (CIP), followed by an air scour and backwash (without chemicals) should be conducted before decommissioning the equipment. Add 4 and 6 liters of storage solution into the feed port of an IP-51 and IP-77 IntegraPac™ module respectively. The module should be kept in the horizontal position at the time of filling, with the remaining ports and openings sealed. Once the target volume of storage solution is added into the module, seal the feed ports and store the modules in the horizontal position. Modules should be placed in a plastic bag for protection and keeping the modules clean.

If the modules will be exposed to freezing conditions glycerin should be added to the storage solution. It is recommended that food grade glycerin be added to the storage solution at the target strength detailed in Table 5. Enough solution should be added to wet the hollow fibers. Completely filling the modules with solution is not required. Modules prepared as described can be stored for 90 days. Consult the manufacturer for storage durations greater than 90 days.

Warranty return of modules:

Review the project warranty information for authorization instructions before shipping modules for return. To prepare a module for shipment drain the module, plug or seal the openings/ports, and secure the module on a pallet or in a crate.

Table 4: Glycerin addition for Freezing Point Depression

Glycerin Wt %	Viscosity cP	Freezing Point Depression ºC	Freezing Point Depression ºF
0.5	1.011	0.07	0.126
3.0	1.074	0.63	1.134
5.0	1.127	1.08	1.944
9.0	1.256	2.06	3.708
12.0	1.365	2.88	5.184
14.0	1.445	3.47	6.246
16.0	1.533	4.09	7.362
20.0	1.737	5.46	9.828
24.0	1.988	7.01	12.62
28.0	2.279	8.77	15.79
32.0	2.637	10.74	19.33
36.0	3.088	12.96	23.33
40.0	3.653	15.50	27.90
44.0	4.443	17.73	31.91
48.0	5.413	20.39	36.70
52.0	6.666	23.22	41.80
56.0	8.349	26.23	47.21
60.0	10.681	29.41	52.94

4. DOW Ultrafiltration IntegraPac™ Process Description

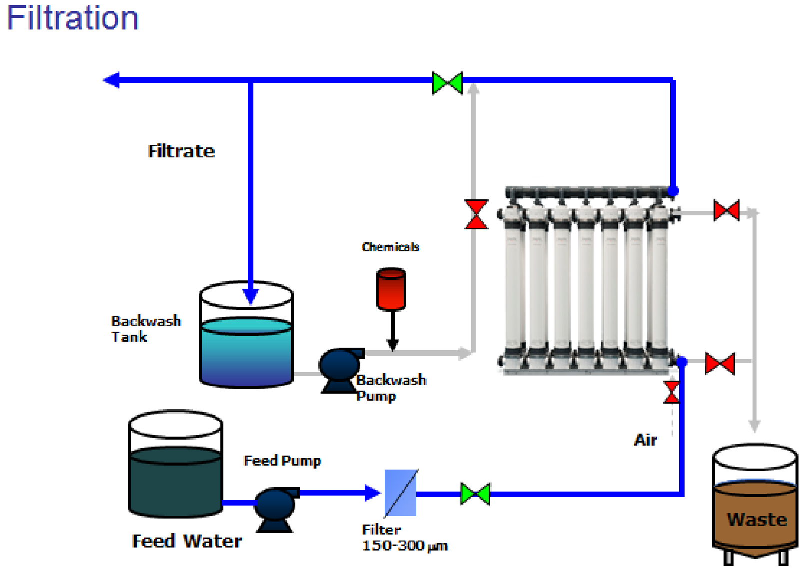
4.1 Process Operations

The basic operating conditions for the DOW Ultrafiltration IntegraPac™ modules and Skids are shown in Table 6 below. Operating parameters for the cleaning steps are provided in the section that describes cleaning.

Table 5: DOW Ultrafiltration IntegraPac™ Modules and Skids Operating Conditions

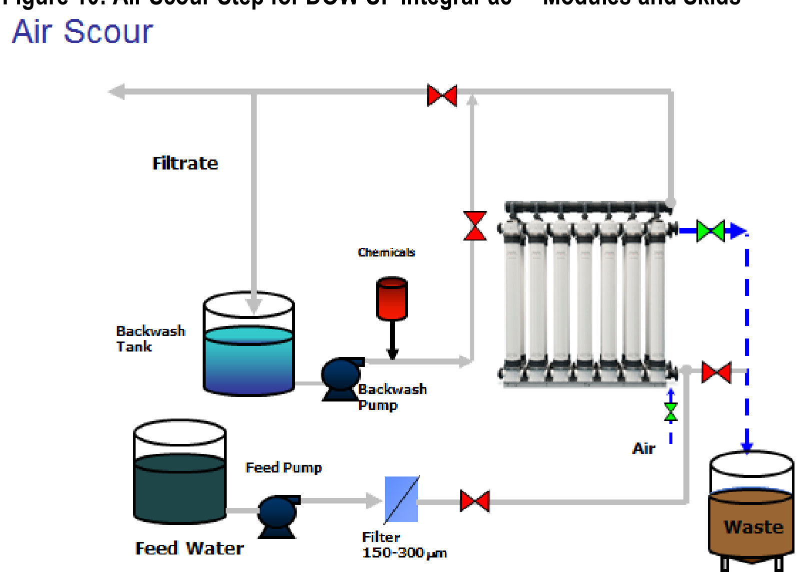
Operating Conditions	SI	US
Feed Pressure, Maximum at Inlet at 20 ºC	6.25 Bar	93.75 psi
Operating TMP (Maximum)	2.1 Bar	30 psi
Backwash TMP (Maximum)	2.5 Bar	36.25 psi
Operating Air Scour Flow (Maximum)	12 Nm^3/hr	7 scfm
Air Scour Pressure	0.35 – 2.5 bar	5.0 – 36.25 psi
Filtrate Flux @25C	40 - 140 $L/m^2/hr$	24 - 82 gfd
Temperature	1 – 40 ºC	34 - 104 ºF
Operating pH Range	2 - 11	
Cleaning pH Range	2 - 12	
NaOCl, Cleaning Maximum	2,000 ppm	

Figure 9: Filtration Step for DOW UF IntegraPac Modules and Skids



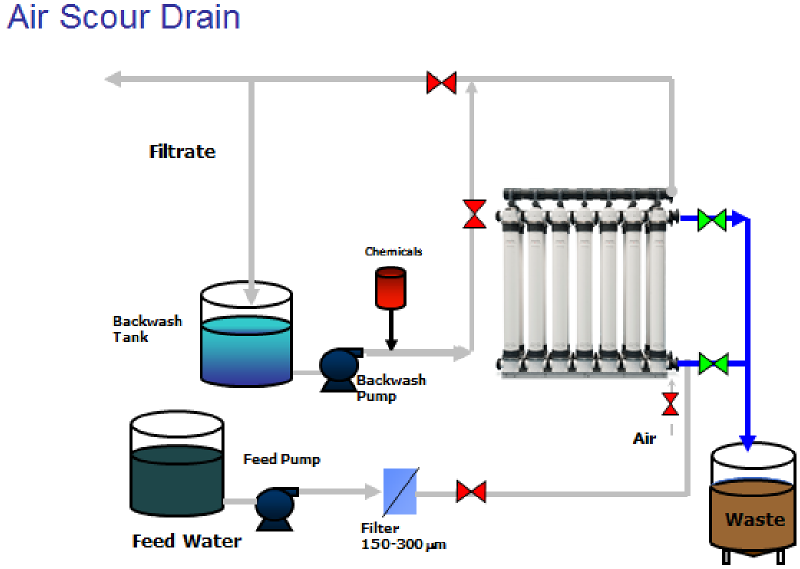
Normal operation refers to the routine operating sequence of a system using the DOW™ Ultrafiltration IntegraPac™ module and includes the operating and backwash steps. Consult Dow for commissioning procedures. At initial start up the modules are flushed using a ***"forward flush"*** to remove any residual chemicals or trapped air from the module. The flush occurs on the outside of the fibers and does not filter the feed water to produce filtrate. After the ***forward flush*** is discontinued the modules can be placed in the ***operating mode***. An operating cycle ranges from 20 to 90 minutes in duration. While operating, 100% of the feed water is converted to filtrate. This is also referred to as dead end filtration. As contaminants are removed and deposited on the hollow fiber membrane surface during the operating step the transmembrane pressure will rise. At the end of the preset operating cycle time, a backwash sequence commences.

Figure 10: Air Scour Step for DOW UF IntegraPac™ Modules and Skids



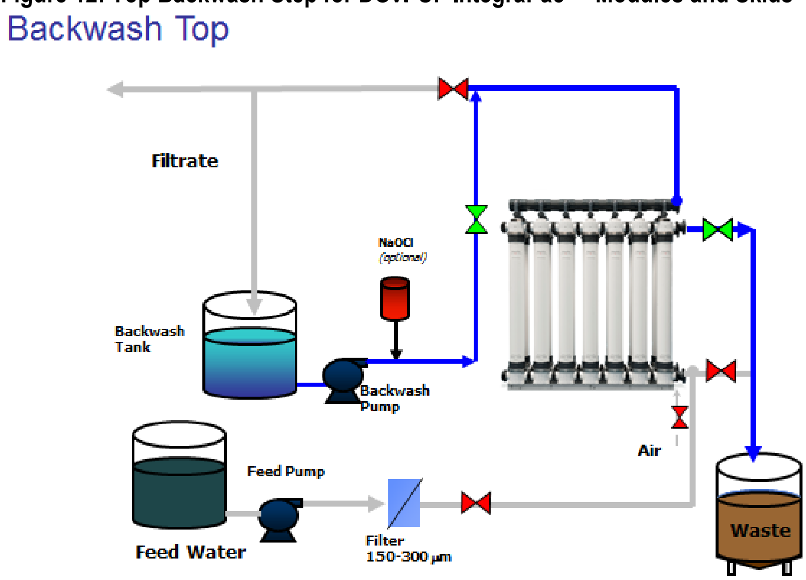
The ***backwash mode*** occurs automatically usually on a preset time basis. The steps include an air scour, draining by gravity, backwash through the top outlet, backwash through the bottom outlet, and a forward flush. The ***air scour*** step is used to loosen particulates deposited on the outside of the membrane surface. Air is introduced on the outside of the fibers using only the hold up water volume of the module. Displaced feed flow/concentrate is allowed to discharge through the top of the module for disposal. After 20 to 30 seconds of continuous or intermittent air scour the module is ***drained*** by gravity.

Figure 11: Air Scour Gravity Drain Step for DOW UF IntegraPac™ Modules and Skids



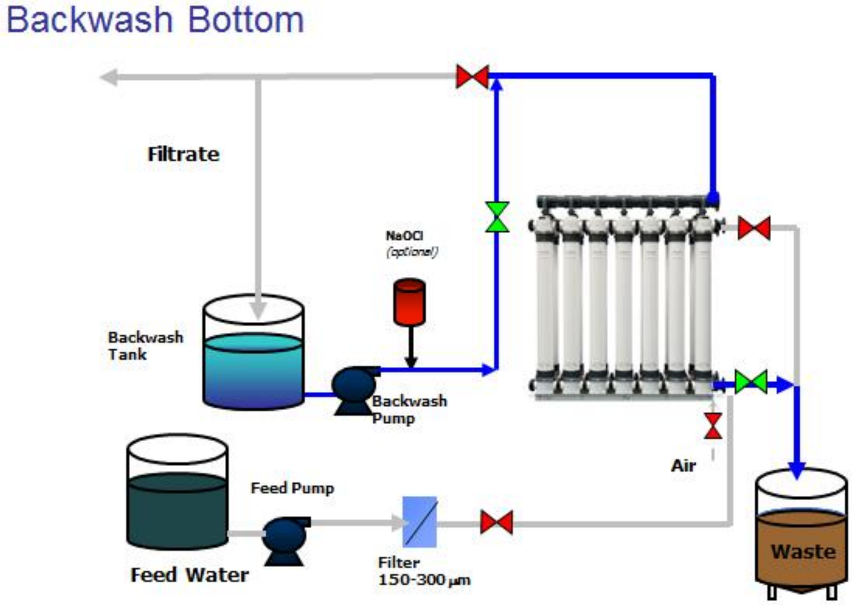
After the gravity draining step, the ***first backwash*** step is performed. Filtrate flow is reversed from the inside of the fiber to the outside and backwash flow is removed from the module housing through the top outlet.

Figure 12: Top Backwash Step for DOW UF IntegraPac™ Modules and Skids



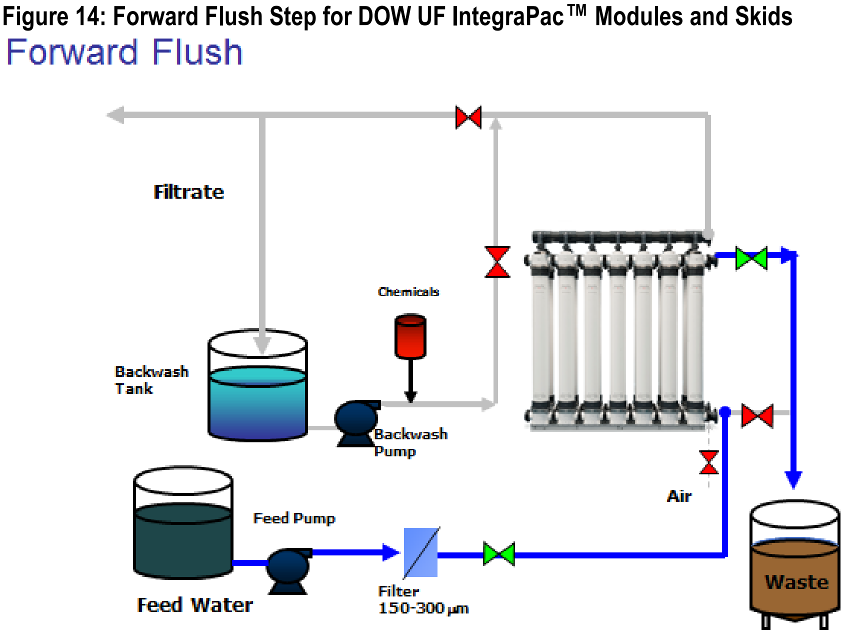
The ***second backwash*** step is performed to remove backwash water through the bottom outlet. Filtrate continues to flow from the inside of the fiber to the outside and backwash flow is removed from the module housing through the bottom outlet of the module, ensuring the entire length of fibers have been cleaned. The backwash steps can be repeated numerous times depending on the degree of fouling. After backwash is complete, a ***forward flush*** is performed to remove any remaining large particulates and air trapped on the outside of the fibers. After a backwash, the modules are returned to the ***normal operating*** mode.

Figure 13: Bottom Backwash Step for DOW UF IntegraPac™ Modules and Skids



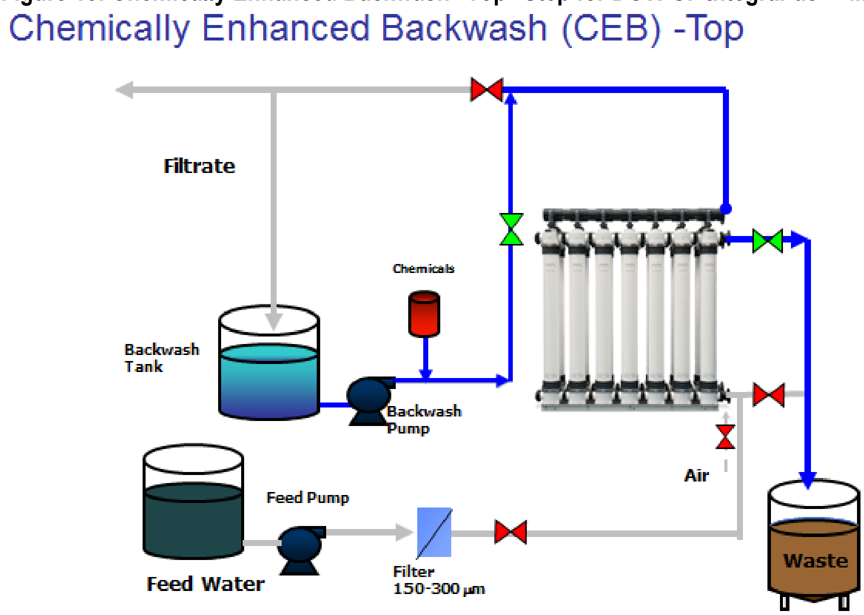
CEB operation refers to a chemically enhanced backwash. The frequency of a CEB is dependent on the feed water quality. On high quality feed waters a CEB may not be required. The CEB process is programmed to occur automatically but the frequency can be field adjusted after gaining site specific operating experience. The CEB is performed using UF filtrate and either an acid, or alkali chemical. The alkali solution can be a combination of oxidant and caustic to more efficiently clean contaminants from the membrane surface. Selection of chemicals is made according the DOW Ultrafiltration applications guidelines and understanding of the foulants in the feed water.

Figure 14: Forward Flush Step for DOW UF IntegraPac™ Modules and Skids



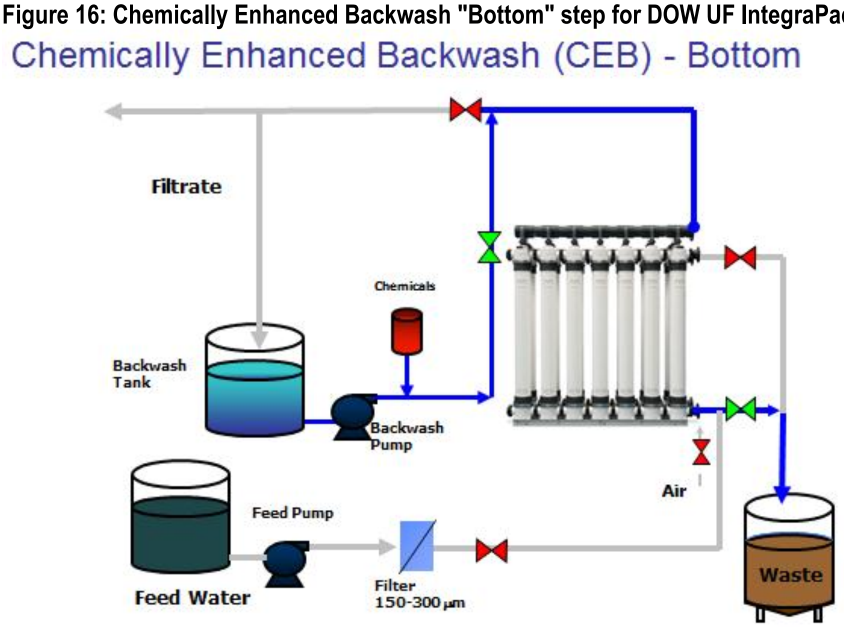
The CEB is performed using the steps of a normal ***backwash*** except during a CEB, chemical is dosed into the backwash water and a soak step is added after the second backwash step. In addition the CEB can be performed at reduced flow, usually 50% of the backwash flux.

Figure 15: Chemically Enhanced Backwash "Top" Step for DOW UF IntegraPac™ Modules and Skids



The ***soak*** is performed for 5 to 20 minutes and allows 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, gravity drain, top and bottom backwash, and forward flush is performed to remove any remaining particulates and purge residual chemicals. After a CEB and at the start of the ***operating*** step, the initial filtrate produced may be sent to waste to remove residual chemicals. This step is dependent on the system piping and valve design and the downstream requirements for the filtrate.

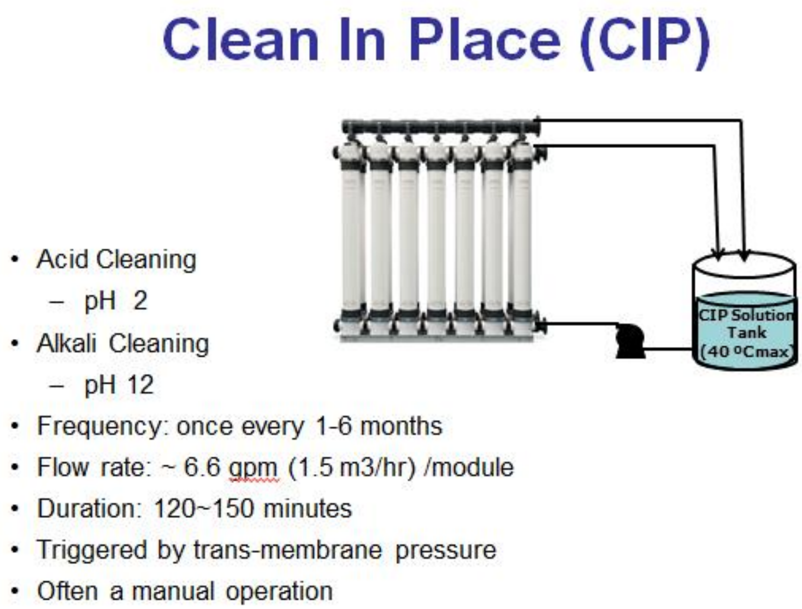
Figure 16: Chemically Enhanced Backwash "Bottom" step for DOW UF IntegraPac™ Modules and Skids



CIP

A clean in place (***CIP***) is an offline operation that includes backwashes and chemical recirculation and soaking to clean the hollow fibers. The CIP is an on demand operation. It can be an automated process but is most often conducted manually. The frequency of a CIP is dependent on the feed water quality and routine fouling control strategy but can range from 1 to 6 months. Prior to a CIP the routine ***backwash*** steps including air scour, draining, backwash through the top outlet, and backwash through the bottom outlet are performed. The backwash steps can be repeated multiple 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 chemical solution. The CIP chemical solutions are ***recirculated*** through the modules on the outside of the hollow fibers for 30 minutes through a chemical mixing and solution tank. A portion of the recycle stream can be passed through the hollow fibers and recycled to the chemical cleaning tank. A cartridge filter is used to remove particulates from the CIP solution during recycle. Note that the CIP solution can be heated to 40ºC to improve effectiveness for removing contaminants from the hollow fibers. The CIP solution pH can be measured during the cleaning process and refreshed with chemicals to maintain the target pH and effectiveness of the solution. A ***soak*** is performed after 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** through the modules on the outside of the hollow fibers for 30 minutes. Air scour for short durations can be performed during the soak and recycle steps to prevent channeling of the solution through the module. When the recycle is completed an air scour is performed and then the module is ***drained*** to remove the concentrated chemical solution. The top and bottom ***backwash*** and the ***forward flush*** steps are also performed to remove any remaining particulates on the outside of the fibers. After a CIP and at the start of the ***operating*** step, filtrate may be sent to waste 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 both an acid and alkali cleaning are required, the CIP steps would be repeated for each chemical solution.

Figure 17: Clean in Place Cleaning Step for DOW UF IntegraPac™ Modules and Skids



4.2 Pretreatment

DOW Ultrafiltration IntegraPac™ Modules and Skids designs are based on qualified feed water conditions as shown in Table 7. The UF IntegraPac™ Modules and Skids can tolerate period excursions in feed water quality as shown as the maximum allowable in Table 7. If the feed water quality is outside of the design basis range Dow should be consulted to determine if a pilot study is needed to confirm performance or if a pretreatment step is necessary. Also, if the membrane filtration system is designed and installed to the conditions below but the feed water quality is not maintained, please consult *Dow Water & Process Solutions*.

Table 6: Qualified Feed Water Quality Parameters

Parameter	Unit	Design Basis	Maximum Allowable
Turbidity	NTU	<50	300
TOC	mg/l	<10	40
Particle Size	micron	<150[1]/300	300
COD_{Mn}	mg/l	<20	60
Oil /Grease	mg/l	0	< 2
pH continuous		6-9	2-11
Temperature	°C	25	40
Cl_2 continuous	mg/l	0.5[2]	200
TSS	mg/l	20	100

[1]Required for seawater applications
[2] Residual in filtrate

Depending on application, a safety screen of 100 - 300 microns is recommended on the feed before the UF IntegraPac™ Modules and Skids. In seawater applications, a strainer size of 100 – 150 microns is recommended to prevent the growth of barnacles and mussel larvae in upstream, process pipework and tanks. A variety of technologies can be used such as self-cleaning screens and filters and bag, cartridge, or disc filters. Depending on the type of water or range of feed water parameters other pretreatment processes such as oxidation, coagulation, clarification and media filtration may also be needed.

4.3 Cleaning

Summary of Information

The process operating parameters for the cleaning steps are provided in Table 8 below.

Table 7: Summary of Cleaning Processes

Backwash Frequency		Once every 20 to 90 minutes (water source or pilot test results)
Backwash Duration		40 to 120 seconds
Backwash Flux		80 to 150 lmh (47 – 90 gfd)
Air Scour	Maximum Inlet Pressure	2.5 bar (36 psi)
	Air flow per Module	5 to 12 Nm^3/h (3-7 scfm)
	Duration	20 to 60 seconds per cycle
	Air- Water Mix Entrance Pressure	0.35 – 2.5 bar (5 – 36 psi)
	Air Quality	Oil-free compressed air ISO 8573.1 Class 1 solids, Class 1 oil
Chemically Enhanced Backwash	Frequency	As needed
	Duration	Backwash Time plus soak 5 to 20 minutes
	Cleaning Solutions	Acid to pH 2 / Alkali to pH 12
Clean in Place	Frequency	When TMP exceeds 1.0 bar above initial TMP (at same temperature)
	Duration	120 minutes (recycle and soak) or longer
	Cleaning Solutions	HCl, Citric, Oxalic, sulfuric to pH 2 0.1%NaOH +0.2% NaOCl to pH 12
	Cleaning Flow per Module	1.0 – 1.5 m3/h (4.4 – 6.6 gpm)
	Temperature Range	10 to 40 °C (50 - 104 °)

4.4 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. To reduce particulates in UF feed water coagulation, sedimentation, clarification, and filtration are often used. The common cleaning method for particulate fouling is air scour and backwash.

Biological fouling is caused by the growth of microorganisms. Using in-line chemical feed of chlorine or biocide or eliminating nutrients by using PAC, GAC, or coagulation, can reduce biological fouling. The cleaning method for removal of biological fouling is Chemically Enhanced Backwash (CEB) with oxidizers or biocides (NaOCl, H_2O_2, SBS). Shock chlorination can also be effective for biological fouling control. Inorganic fouling is caused by the precipitation of inorganics on the membrane. The rate of inorganic fouling can be controlled through oxidation/precipitation and/or filtration as pretreatment to the UF or in some cases reducing the hardness of the feed water. The recommended cleaning method for removal of inorganic fouling is chemically enhanced backwash with acid at pH 2 (HCl, H_2SO_4, Citric, Oxalic Acid).

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

5. Operating Information

5.1 Start Up

The following procedures should be followed for start-up of DOW™ IntegraPac™ Ultrafiltration Modules and Skids. Manually start the equipment during initial operation. Flush the UF system to remove the storage solution used in shipping before starting the equipment. Target a filtrate flow of 60% of design during initial operations. After 24 hours the filtrate flow can be adjusted to design conditions.

Pre-start checks

1. The UF pre-treatment system should operate properly and the UF feed water should meet the design requirements. Ensure that chemical addition points are properly located and that proper mixing of chemicals in the feed streams can occur. Check the addition of pretreatment chemicals.
2. Verify that the drain/waste collection system is functional
3. Verify that the PLC program is loaded and functioning
4. Complete an electrical system check. Verify that the instrumentation is working and calibration is completed. Calibrate gauges and meters based on manufacturers' recommendations.
5. Clean and connect interconnecting piping. Flush system without modules to remove fabrication debris. During the flushing operation, check all pipe connections and valves for leaks. Tighten connections where necessary.
6. Residual air should be removed from the system during start-up.

Start Up

Check that all valves are closed and pumps are off before starting the system. Start the equipment by following the steps below:

1. Pumps should be aligned, lubricated, and properly rotated.
2. Open valves and start the feed pump
3. Fill system and start a flush
4. Start the backwash pump
5. Set and adjust the backwash pressure
6. Set and adjust the inlet air pressure
7. Set backwash time interval
8. Set air scour time interval
9. Set backwash sequence

Module Rinsing

The DOW IntegraPac™ Ultrafiltration modules should be rinsed prior to startup to remove storage solution shipped in the modules. Flushing should be performed until no foam is observed in the waste stream generated. Depending on the treatment application, additional rinsing or disposal of the filtrate may be required.

NSF / ANSI Standard 61 certified modules require the following conditioning rinse prior to producing potable water:

1. Rinse the modules at a feed rate of 40 LMH minimum for a period of 4 Hours.
2. Achieve a minimum total rinse volume of 160 LMH-Hours using the feed water available.
3. The concentrate bleed rate should be set between 0% and 20% with the balance being filtrate.
4. During the rinse cycle, perform standard cleaning procedures (e.g. backwash) per the design projection or Dow's recommendations based on the feed water quality data.
5. The rinse filtrate should be sent to the appropriate disposal system based on the regulations that apply to the location where the conditioning rinse is carried out and not used as potable water.
6. Local regulations may require additional conditioning of the system prior to producing potable water.

5.2 Integrity Testing procedures

There are two methods used to perform an integrity test: a visual inspection test and pressure decay test. .

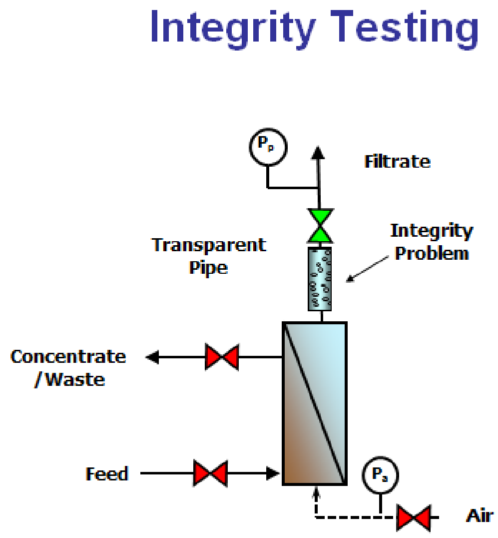
Pressure hold/decay

1. Take the UF unit or module out of the filtration mode. Drain the water from the feed side of the module. Close the feed and concentrate valves (see Figure 18) and keep the filtrate valve open.
2. Pressurize the feed side of the membrane modules with oil free compressed air from the air inlet valve, and slowly raise the air pressure to a maximum of 2 bars (29 psi). A minimum test pressure of 18 psi will allow detection of 3 micron particles. Expect some water to flow from the hollow fibers to the filtrate.
3. Close the air inlet valve and allow the pressure to stabilize
4. Hold the pressure for 10 minutes. The membrane is integral (no leaks) if the pressure drop is lower than 0.2 bar (2.9 psi). If the pressure drop is greater than 0.2 bar in 10 minutes (2.9 psi in 10 minutes) then membrane fibers might be compromised and require repair.
5. Repair the membrane following the "fiber test and repair procedure".

Visual Inspection Test

During the pressure hold/decay test, leaking modules can be identified through the transparent section of filtrate piping. As the system is being pressurized with oil-free compressed air from the air inlet valve at a maximum of 2 bars (29 psi), large continuous air bubbles may appear in the transparent filtrate piping. This indicates that the specific module may have broken fibers or damaged seals. Smaller and infrequent bubbles are the result of air diffusion through the pores of the ultrafiltration membrane.

Figure 18: Pressure Hold Test Schematic



5.3 Shut Down

Manual shut down

To conduct a manual shut down open the concentrate rinse valve and flush for 15 seconds. Then stop the feed pump and slowly close the inlet valve.

Equipment shut down during automatic operation

The equipment will automatically stop or will not allow automatic operation if the feed pump did not start when operation was initiated or the inlet or filtrate pressure is too high to operate or there is a loss of power. Valves should fail closed.

Please refer to the module storage and preservation steps before shutdown to allow proper module maintenance be performed.

5.4 Operating and Cleaning Logs

Recording data is useful for tracking operating conditions and to optimize operations. The frequency of data collection will depend on the use of the filtrate water or regulatory requirements. Attached are two logs including the Data Log Sheet for normal filtration and operations and the CIP Record Sheet, which is used to collect information from the Clean in Place process.

DOW™ Ultrafiltration Data Log Sheet			
Customer:			
System Information: (pretreatment process, chemical feed type and dosages, etc):			
UF Module Type:	**Number of Skids:**	**Number of Modules/skid:**	**Membrane Area:**
Date:	**Time:**	**Cumulative hours of operation:**	**Recorded By:**
Parameters	**Unit**	**Recorded Value**	**Comments**
Data Collected			
Temperature (T)	ºC or ºF		
Pre-filter Inlet Pressure	Psi or bar		
Pre-filter Outlet Pressure	Psi or bar		
UF Feed Pressure (P_f)	Psi or bar		
UF Filtrate Pressure (P_p)	Psi or bar		
UF Concentrate Pressure (P_c)	Psi or bar		
UF Filtrate Flow / skid (Q_p)	gpm or m^3/hr		
UF Backwash Flow / skid (Q_{bw})	gpm or m^3/hr		
UF Forward Flush / skid (Q_{ff})	gpm or m^3/hr		
Filtration time per cycle (t_f)	minutes		
Backwash time per cycle (t_{bw})	seconds		
Forward flush time per cycle (t_{ff})	seconds		
Air Scour time per cycle	seconds		
CEB Alkali frequency	hours		
CEB Alkali pH	---		
CEB Acid frequency	hours		
CEB Acid pH	---		
UF Feed Turbidity	NTU		
UF Filtrate Turbidity	NTU		
UF Feed TSS	ppm or mg/L		
UF Filtrate TSS	ppm or mg/L		
UF Filtrate SDI_{15}	---		
Performance			
Gross Flux (J)	Gfd or lmh		
Transmembrane Pressure (TMP)	Psi or bar		
Permeability ($L_{N, 20}$)	Gfd/psi or lmh/bar		
Equations to Calculate Performance			
Transmembrane Pressure (TMP) = P_f - P_p			
Recovery (R) = (Q_p* t_f - Q_{bw}* t_{bw}) / (Q_p* t_f + Q_{ff} * t_{ff}) * 100			

DOW™ Ultrafiltration CIP Record Sheet				
Customer:				
System Information: (pretreatment process, chemical feed type and dosages, etc)				
UF Module Type:	**Number of Skids:**	**Number of Modules/skid:**	**Cumulative hours of operation:**	**Total number of cleaning:**
Date:	**Time:**	**Cumulative hours of operation after last cleaning:**		**Recorded By:**
Item	**Unit**	**First Solution**	**Second Solution**	**Remarks**
Pre-cleaning Air Scour and Backwash				
Backwash Water Source	---			
Backwash Flux	LMH or gfd			
Air flow rate per module	Nm^3/h or scfm			
Cleaning Chemicals				
Volume of cleaning solution	Liters or gallon			
Acid (also list type used)	Liters or gallon			
Caustic soda (%)	Liters or gallon			
Sodium hypochlorite (%)	Liters or gallon			
Others Chemicals	Liters or gallon			
CIP Operating Conditions				
Solution concentration	%			
pH	---			
Temperature	ºC or ºF			
Circulation flow rate	m^3/h or gpm			
Duration of initial circulation	Minutes			
Soaking period	Minutes			
Duration of final circulation	Minutes			
Final Backwash or Flush/Rinse				
Source of water	---			
Flow rate	m^3/h or gpm			
Duration	Minutes			
pH of waste streams	---			

For more information about DOW IntegraPac, call the Dow Water & Process Solutions business:
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