PALL Life Sciences

Quick Reference

USTR 2453b

T-Series TFF Cassettes with Omega™ and Delta Membranes

For use with Centramate™ and Centrasette™ TFF Systems

*Filtration. Separation. Solution.*SM

Contents

Safety Notice

Important Notice
Refer to safety instructions before use. Safety instructions in this language are available from Pall.

Viktigt att notera
Läs säkerhetsinstruktionerna före användandet.
Säkerhetsinstruktioner på svenska finns att få från Pall.

重要通知
ご使用前に安全にお使いいただくための説明書をお読みください。
日本語でかかれた説明書はポールより入手可能です。

Viktig melding
Les Sikkerhetsinstruksjonen før bruk.
Sikkerhetsintruksjon på norsk vil være tilgjengelig fra Pall.

Belangrijke informatie:
Voor gebruik veiligheidsinstructies goed doornemen.
Veiligheids instructies in het Nederlands zijn bij Pall verkrijgbaar.

Avvertenza importante
Prima dell'uso leggere le istruzioni per la sicurezza.
Le istruzioni per la sicurezza in Italiano possono essere richieste a Pall.

Aviso importante
Antes de utilzar, consultar instruções de segurança.
Instruções de segurança em Português, encontram-se disponiveis na Pall.

Aviso importante
Antes de usar, consultar Instrucciones de Seguridad.
Instrucciones de Seguridad en este idioma están disponibles por Pall.

Important
Se référer aux instructions concernant la sécurité d'utilisation avant usage.
Les instructions concernant la sécurité d'utilisation sont disponibles en français chez Pall.

Vigtigt
Læs sikkerhedsinstruktioner før ibrugtagning.
Sikkerhedsinstruktioner på dansk kan fås fra Pall.

Tärkeä tiedote
Lue turvallisuusohjeet ennen käyttöä.
Pall toimittaa tarvittaessa suomenkieliset turvallisuusohjeet.

Wichtige Anmerkung
Vor Gebrauch bitte die Sicherheitsrichtlinien lesen. Die Sicherheitsrichtlinien in dieser Sprache erhalten Sie von Pall.

Σημαντική Επισήμανση:
Διαβάστε τις Οδηγίες Ασφάλειας πριν από τη Χρήση.
Οι Οδηγίες Ασφάλειας στα Ελληνικά είναι διαθέσιμες από την PALL.

Learn About Safety

Please read and follow the safety instructions in this User Guide.

Important — Read First

Storage solutions recommended for sanitizing, cleaning, flushing, and storage may be hazardous or corrosive. Follow proper safety procedures when preparing, mixing, and handling these reagents. Refer to Material Safety Data Sheets (MSDS), available from your supplier, to learn about the specific characteristics, necessary precautions, and suitable remedies for each reagent used.

1. Always wear protective clothing including safety glasses and gloves when working with membrane cassettes, equipment, samples, and reagents.
2. Provide sufficient space for assembling all system components and operating the system.
3. Disconnecting a system component or dismantling an installed cassette holder without first isolating and depressurizing it can result in personal injury and equipment damage. Depressurize a TFF system and cassette holder before dismantling any component.
4. Some system components may be very heavy. Take proper precautions when moving or lifting equipment to prevent personal injury. In some cases, hoists or other lifting equipment may be required.
5. You should always use pressure gauges or pressure sensing devices in your system so you can monitor the system pressure and differential pressure across the membrane cassette.
6. Take suitable precautions before sterilizing the holder with steam or using the holder with hot fluids.
7. Do not use your cassette holder as a coded pressure vessel.
8. Wipe up spills promptly to prevent injury from contact or slipping.
9. Complete the following safety procedures:
   a. Read about the operating limits of the membrane cassette and the proper methods for use detailed in this T-Series TFF Cassettes with Omega and Delta Membranes Quick Reference.
   b. Ensure that your process and cleaning conditions do not exceed the operating limits of the cassette holder, membrane cassette, and sealing materials.
   c. Check that your process equipment and the cassette holder meet local safety codes.
   d. Inspect the holder and seals regularly to detect damaged components.

Safety Conventions in this Manual

Safety information is identified in this instruction manual by the following conventions.

Information

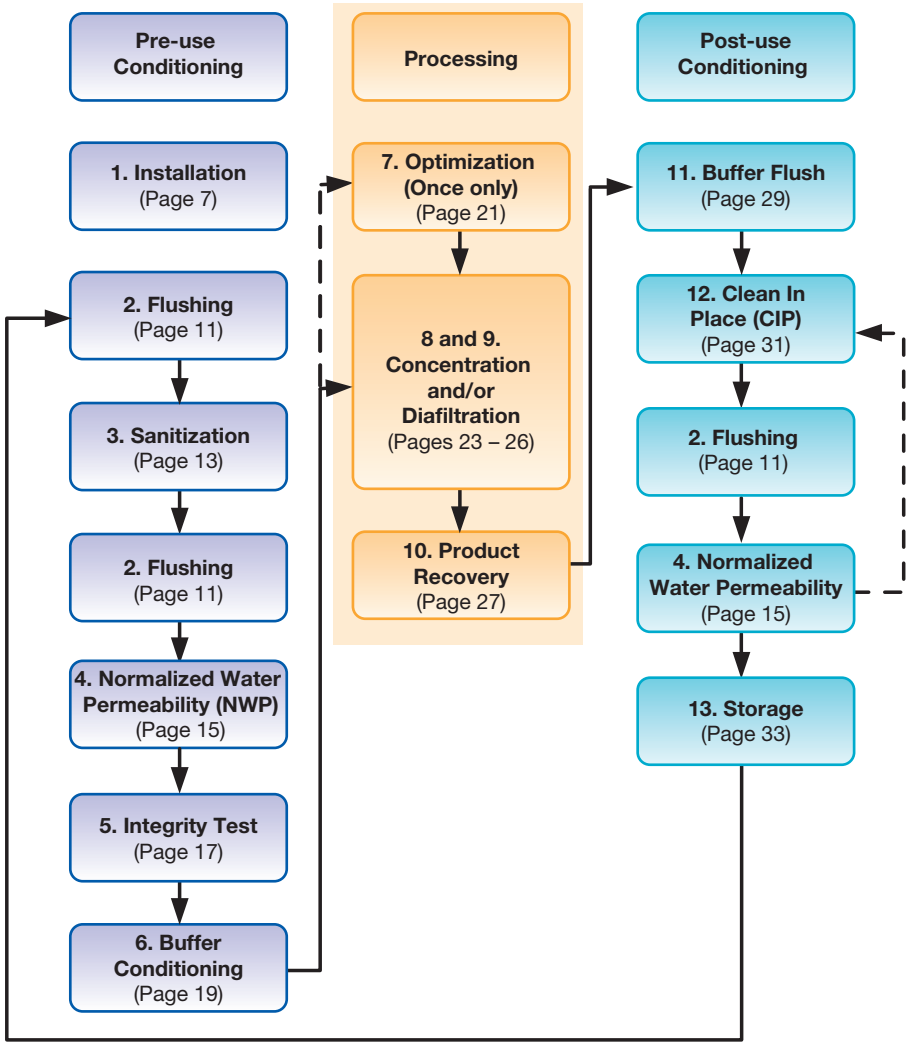
Information: Identifies important information about the current topic.

Safety Warning

Warning: Safety concerns are identified with a yellow warning triangle. The symbol identifies a dangerous or potentially dangerous situation that may cause irreversible damage to equipment and poses a safety risk that can cause serious personal injury.

TFF Process Flowchart

Figure 1
TFF Process Flowchart

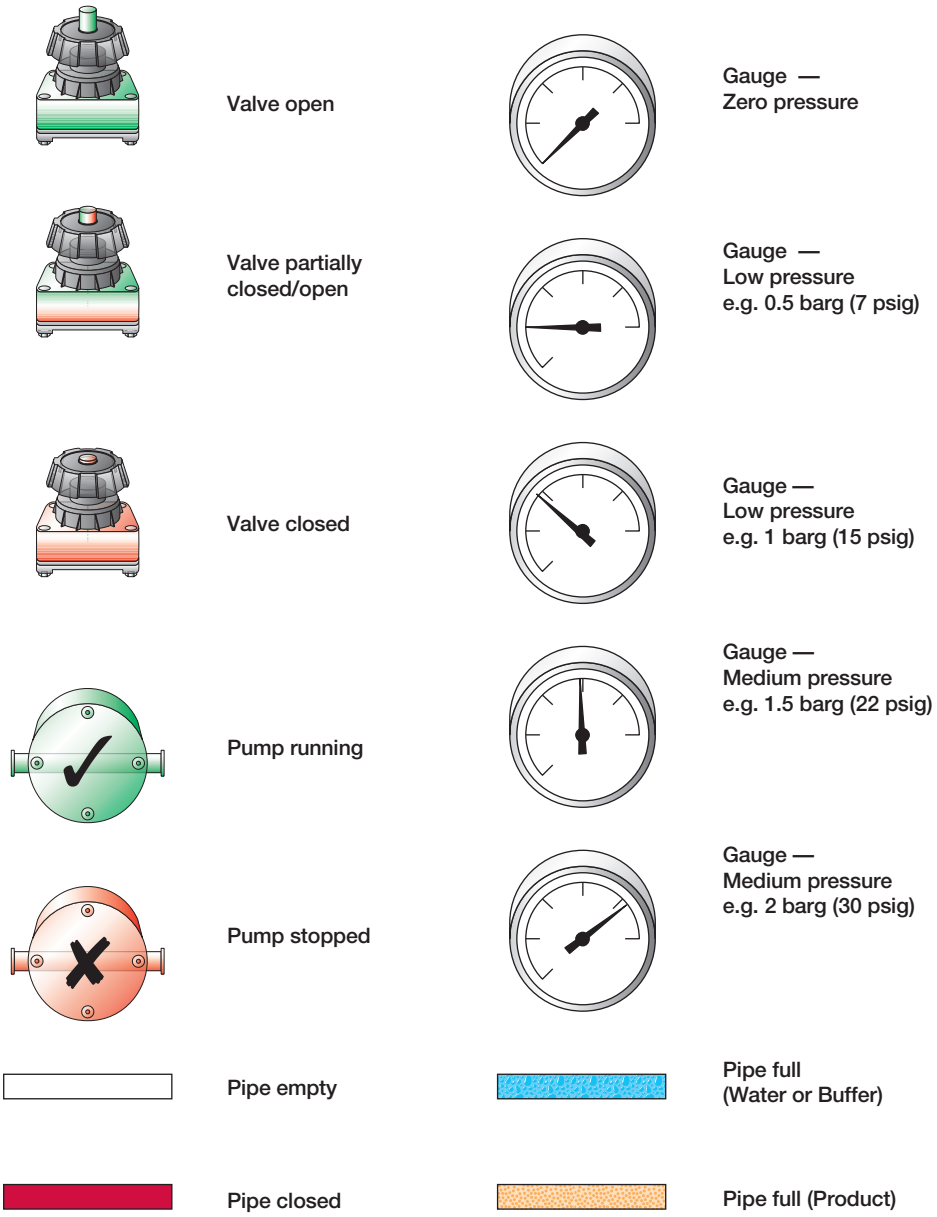


Note: The specific steps and order of steps for processing are application specific and must be established by the user. Basic guidelines are shown in this abridged manual. Pall can assist with optimizing your process.

Introduction and Key to Diagrams

This manual supplements the T-Series TFF Cassettes with Omega Membrane Care and Use Procedures (USD 2433b) and T-Series TFF Cassettes with Delta Membrane Care and Use Procedures (USD 2662). Refer to recommended flow rates and operating specifications for the Pall range of membrane cassettes. This manual contains operating guidelines. All process steps should be validated by a qualified individual.

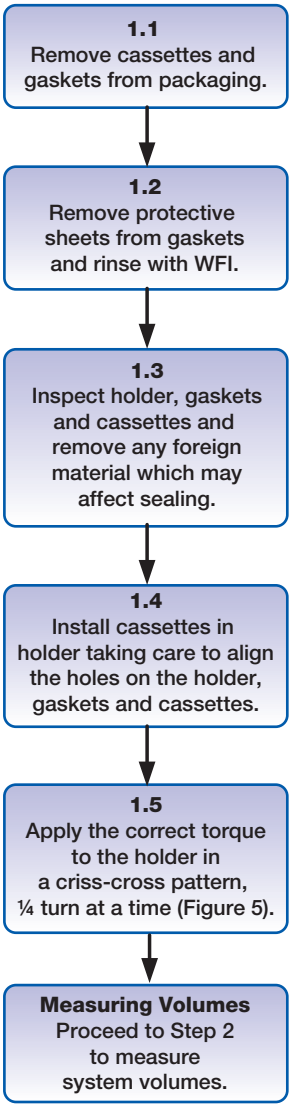
Figure 2
Key to Diagrams



Step 1. Installation

Figure 3

Installation Flow Diagram



Wear gloves to avoid contact with storage solutions.

Ensure that a gasket is positioned between each interface as shown in Figure 4.

Please refer to T-Series Membrane Cassette Care and Use Procedures (USD 2433b and 2662).

Install multiple cassettes with the printed cassette information facing the same side and direction, so that it can be read.

Figure 4

Example of Multiple Cassette Installation

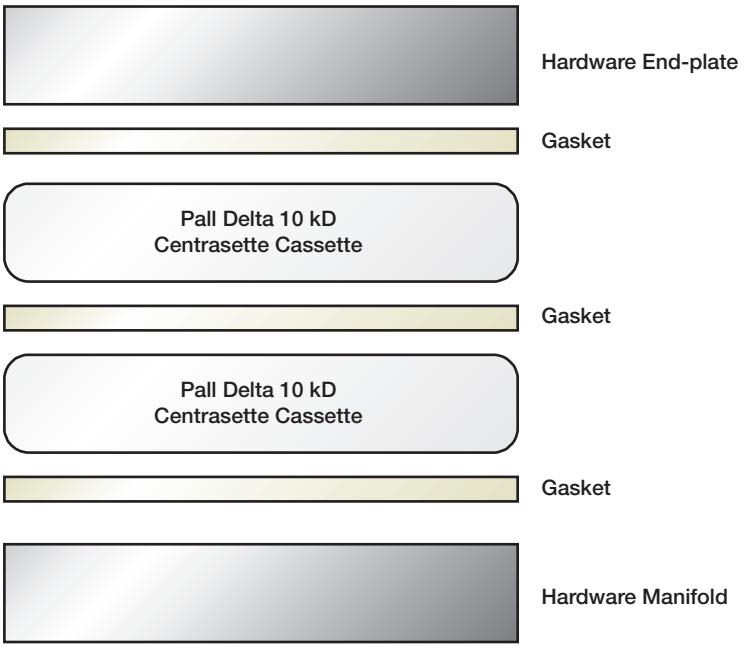
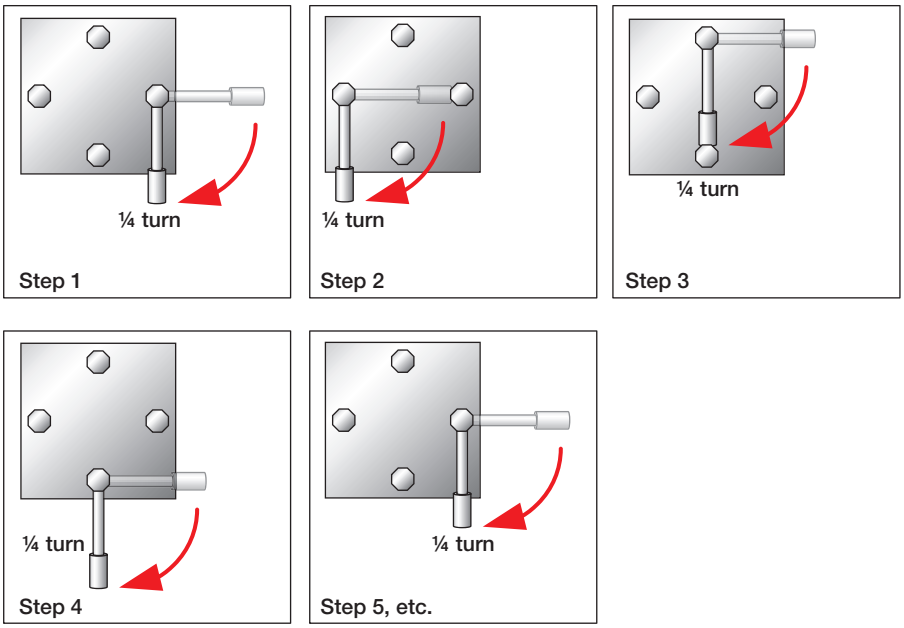


Figure 5

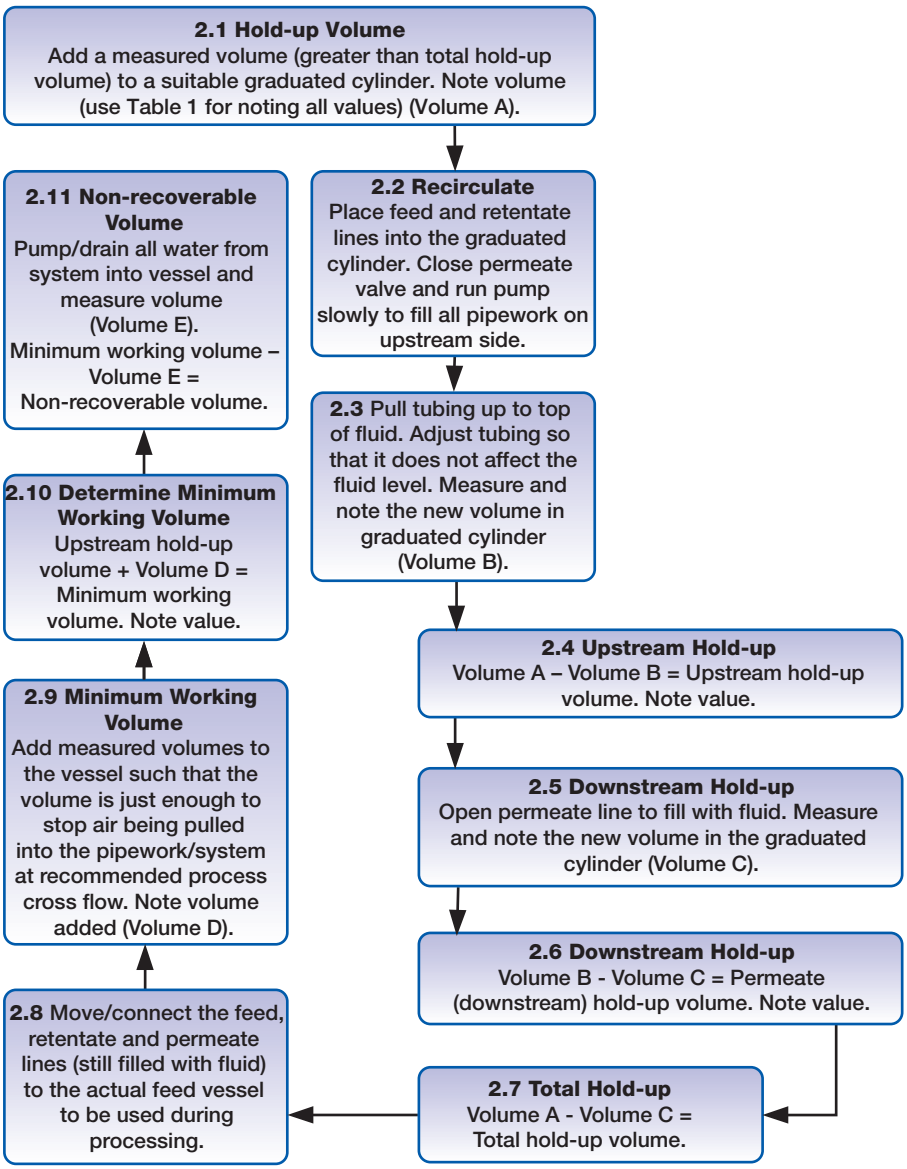
Example of ¼-turn Torque Procedure



Step 2. Measuring Critical Volumes

Figure 6

Measuring Volumes Flow Diagram



To measure volumes you will need appropriate sized graduated cylinders.

This procedure is a guideline only and will not cover all setups. Depending on system setup, this procedure may need to be adjusted (e.g., if the feed vessel is connected directly to the pump).

Figure 7

Setup for Hold-up Volume — Volume A (Step 2.1)

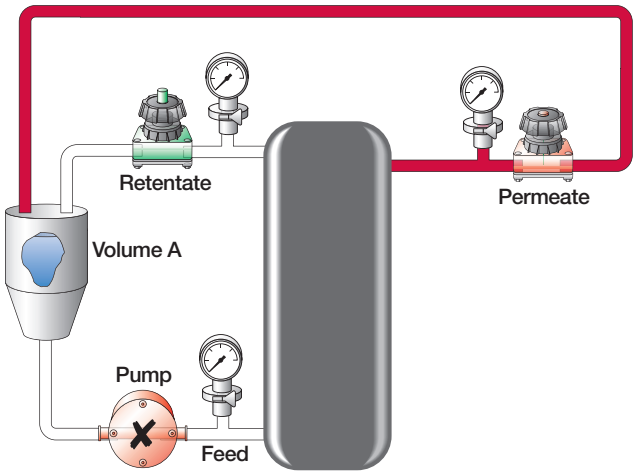


Figure 8

Volume B (Step 2.3)

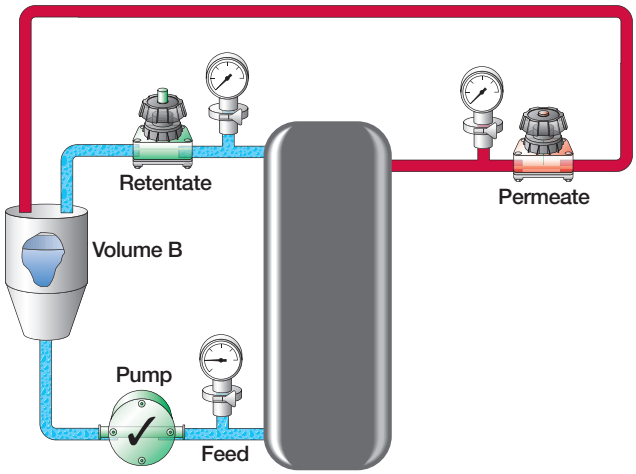


Figure 9

Volume C (Step 2.5)

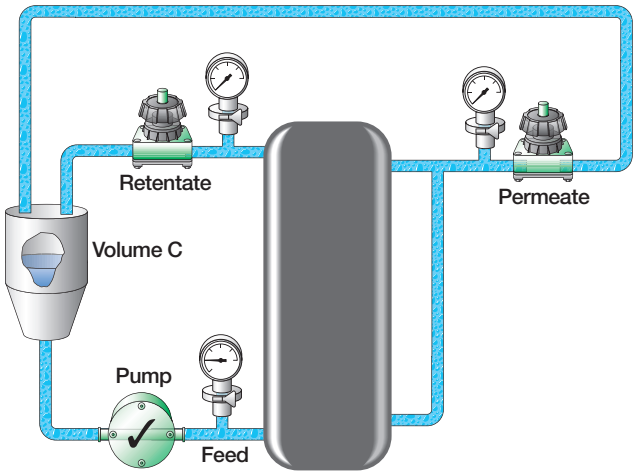


Figure 10

Minimum Working Volume at Process CFF (Step 2.9)

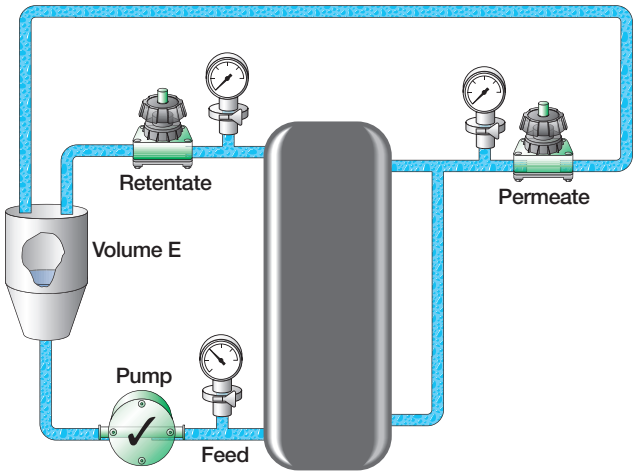


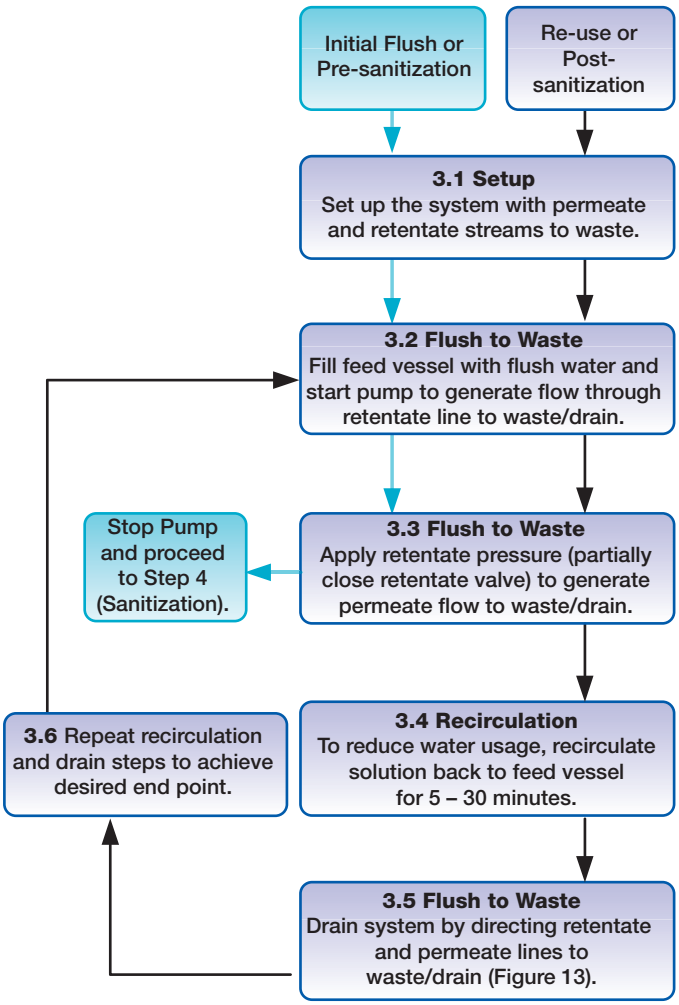
Table 1

Measured Volumes

Volume Tag	Description	Measured/Noted Value
Volume A	Initial Volume	
Volume B	Vessel Volume after Step 2.3	
Upstream	Hold-up Volume (Volume A – Volume B)	
Volume C	Vessel Volume after Step 2.5	
Permeate	Hold-up Volume (Volume B – Volume C)	
Total Hold-up	Volume (Volume A – Volume C)	
Volume D	Volume added during Step 2.9	
Minimum Working Volume	Upstream Hold-up Volume + Volume D	
Volume E	Volume recovered during Step 2.11	
Non-recoverable Volume	Minimum Working Volume – Volume E	

Step 3. Flushing

Figure 11
Flushing Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Before the flushing procedure, it is recommended that system hold-up and minimum working volumes be established. See Step 2 for example.

Recirculation times and volumes are application specific and must be validated. Flush system with pharmaceutical grade water. Use of a lower quality water may introduce inorganic impurities that could affect membrane performance and product recovery.

During flushing it is also recommended to calibrate the pump (determine the speed settings to achieve required process and CIP cross flow rates).

Figure 12

Setup for Retentate and Permeate to Waste (Step 3.1)

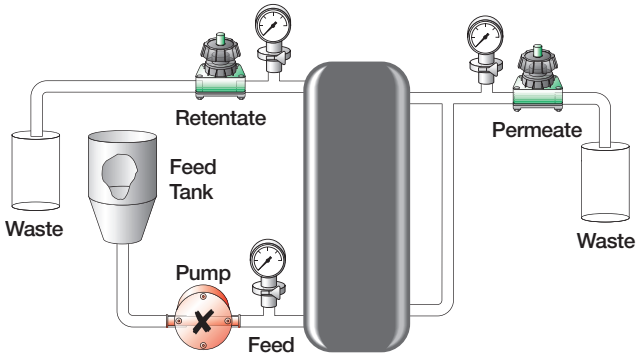


Figure 13

Retentate and Permeate to Waste (Steps 3.2 and 3.5)

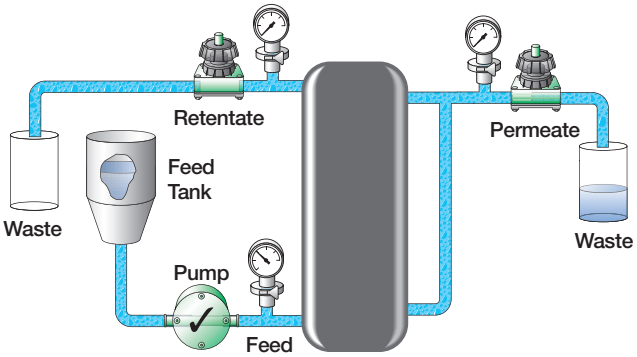


Figure 14

Flush to Waste with Pressure (Step 3.3)

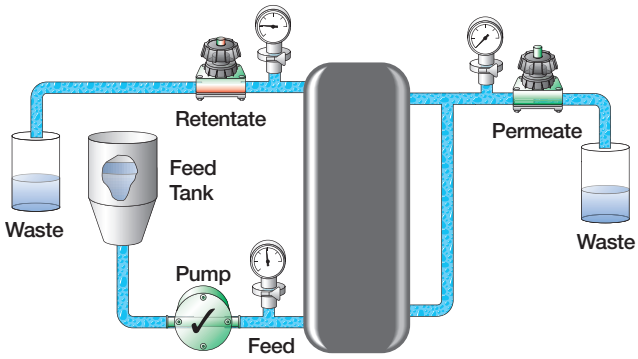
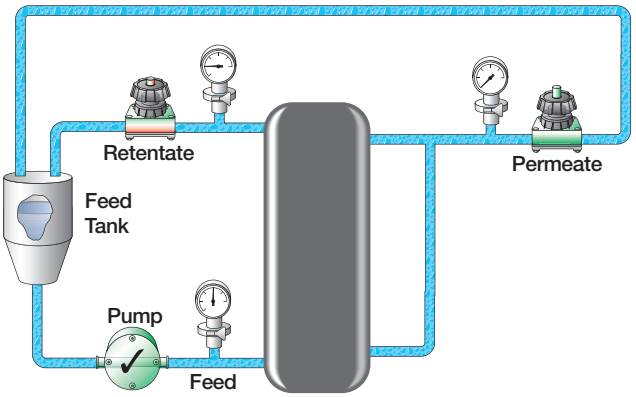


Figure 15

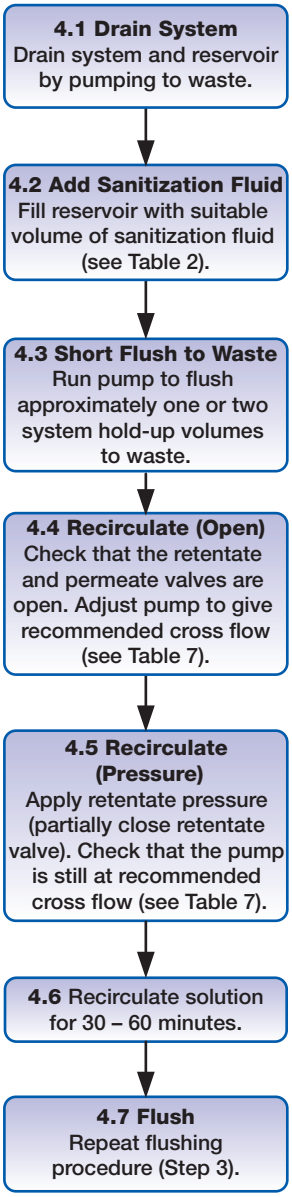
Recirculation with Pressure (Step 3.4)



Step 4. Sanitization

Figure 16

Sanitization Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Ensure you use a large enough volume to enable an initial purge to waste followed by recirculation. Recirculation times and volumes are application specific. Must be validated. Please refer to T-Series Membrane Care and Use Procedures (USD 2433b and 2662).

Sanitization retentate flow rate should be 1.5 x process retentate flow rate.

Figure 17

Retentate and Permeate to Waste (Steps 4.1 – 4.3)

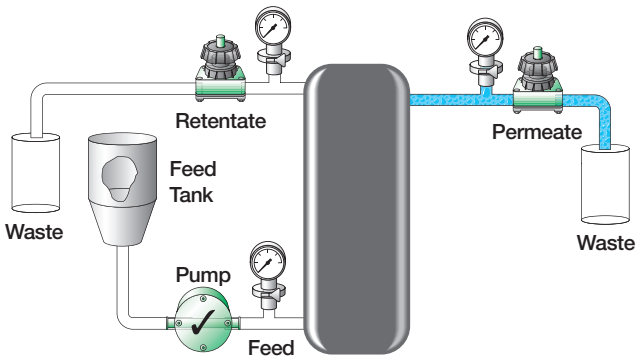


Figure 18

Recirculation with Permeate and Retentate Open (Step 4.4)

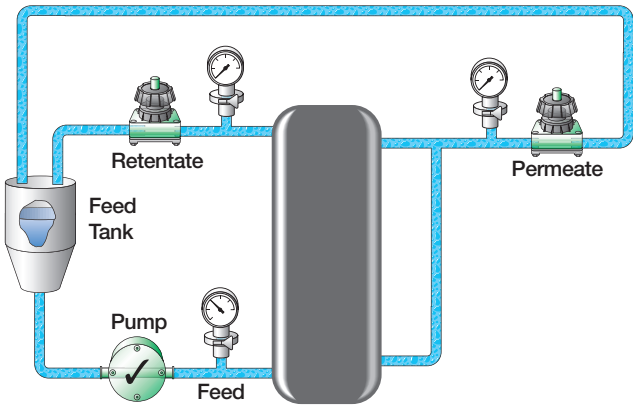


Figure 19

Recirculation with Pressure (Step 4.5)

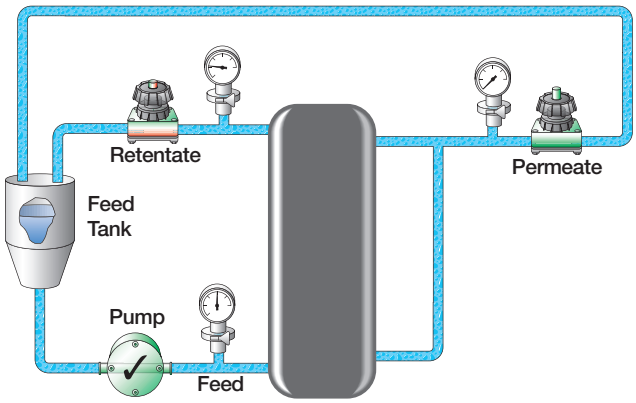


Table 2

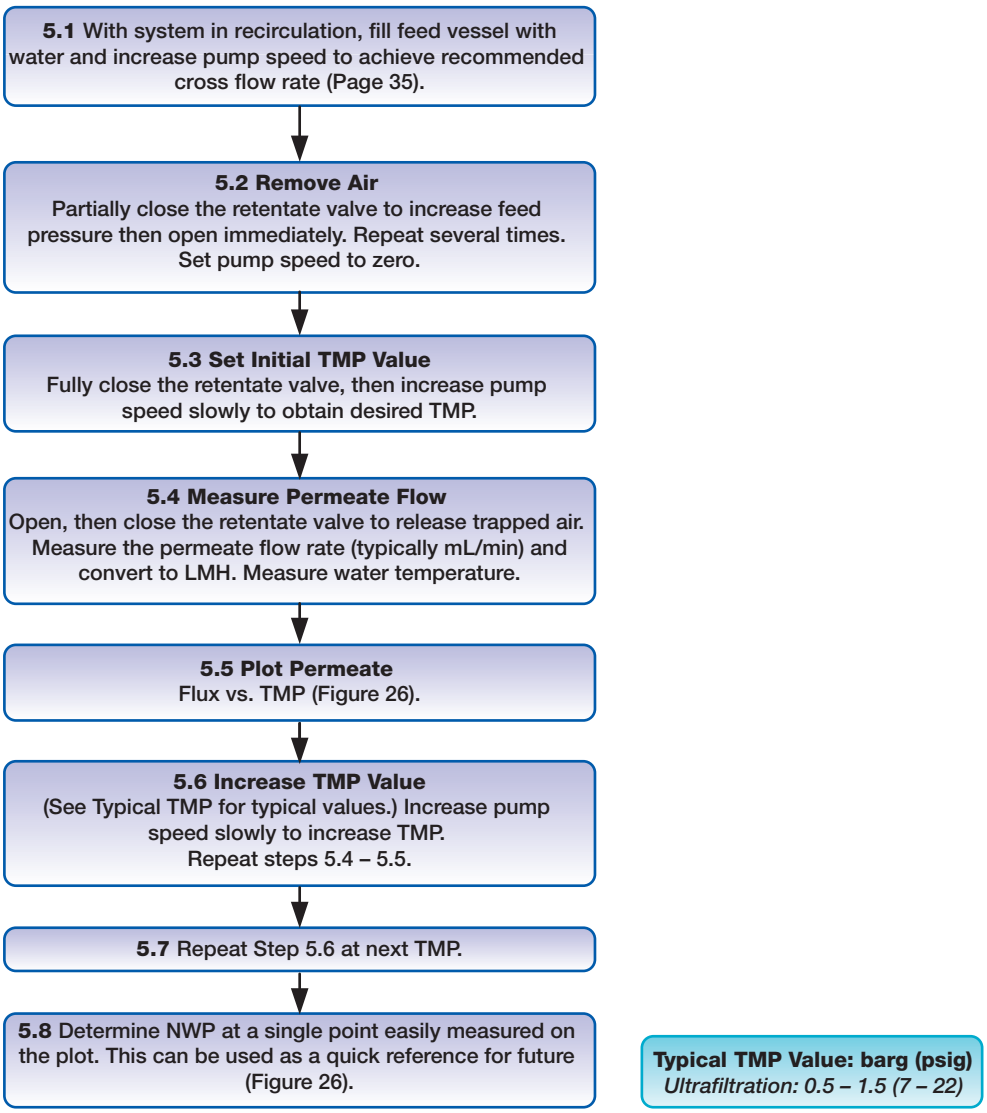
Recommended Sanitization Solutions and Conditions

Membrane Type	Choose an Appropriate Solution from the List Below	Temperature
Omega	0.1 N Acetic Acid ($C_2H_4O_2$) 0.1 N Phosphoric Acid (H_3PO_4) 0.1 – 0.5 N NaOH 0.1 – 0.5 N NaOH + 200 – 400 ppm NaOCl 10 – 50 ppm NaOCl pH 6 – 8	25 – 45 °C
Delta	0.1 N Acetic Acid ($C_2H_4O_2$) 0.1 N NaOH	25 – 45 °C

Step 5. Normalized Water Permeability (NWP)

Figure 20

Normalized Water Permeability (NWP) Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Water quality should be Water For Injection (WFI) or at a minimum 0.2 µm filtered DI.

The initial $NWP_{20°C}$ of the cassette is essential to calculate because it is used as the basis to determine membrane recovery.

Be sure to use calibrated equipment that is accurate in the measurement range.

Figure 21

Recirculation (Step 5.1)

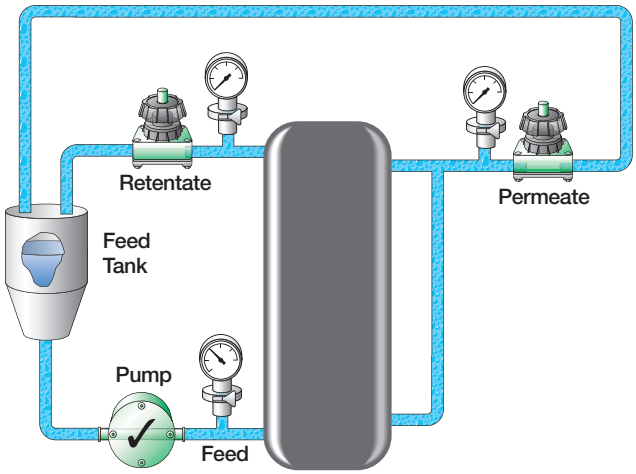


Figure 22

Pressure Increase to Remove Air (Step 5.2)

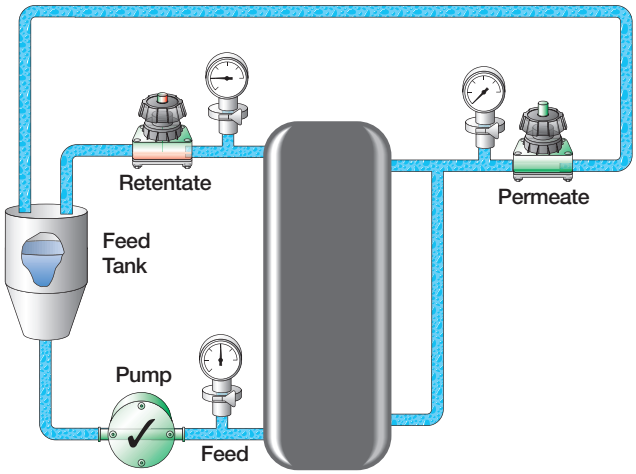
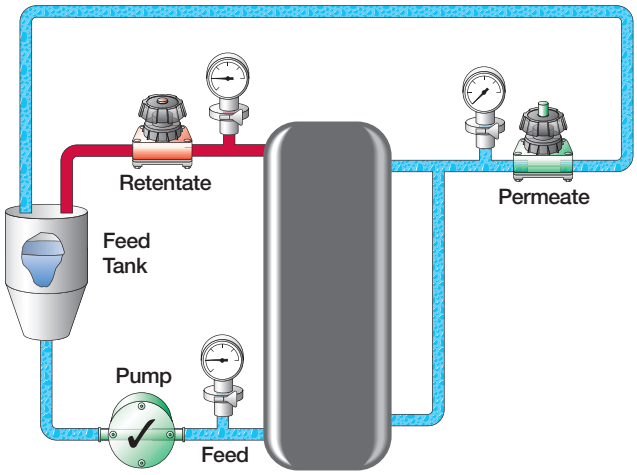


Figure 23

Using Pump to Obtain Desired TMP (Step 5.3)



Equations

$TMP = ([P_F + P_R]/2) - P_P$

$$\text{Water Perm} = \frac{\text{Permeate Flux (LMH)}}{\text{TMP (barg or psig)}}$$

$$NWP_{20°C} = \frac{LMH}{TMP} \times TCF^*$$

$$\text{Membrane Recovery} = \frac{\text{NWP after cleaning}}{\text{NWP initial}} \times 100\%$$

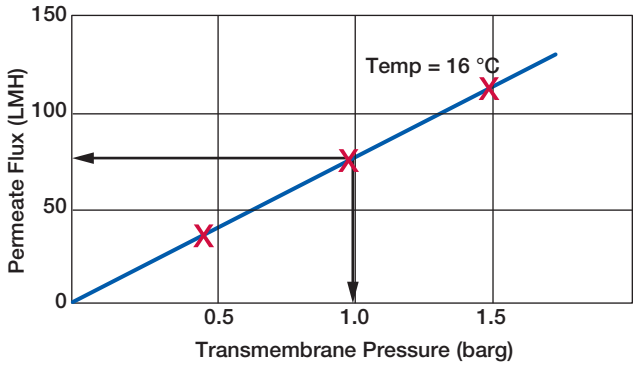
Conversions

1 barg = 14.5 psig

*TCF = Temperature Conversion Factors (Table 10)

Figure 24

Determining NWP for a Membrane Cassette



Equations

Water Permeability = 75 LMH @ 1 barg

$NWP_{20\,°C}$ = 75/1.0 barg X TCF

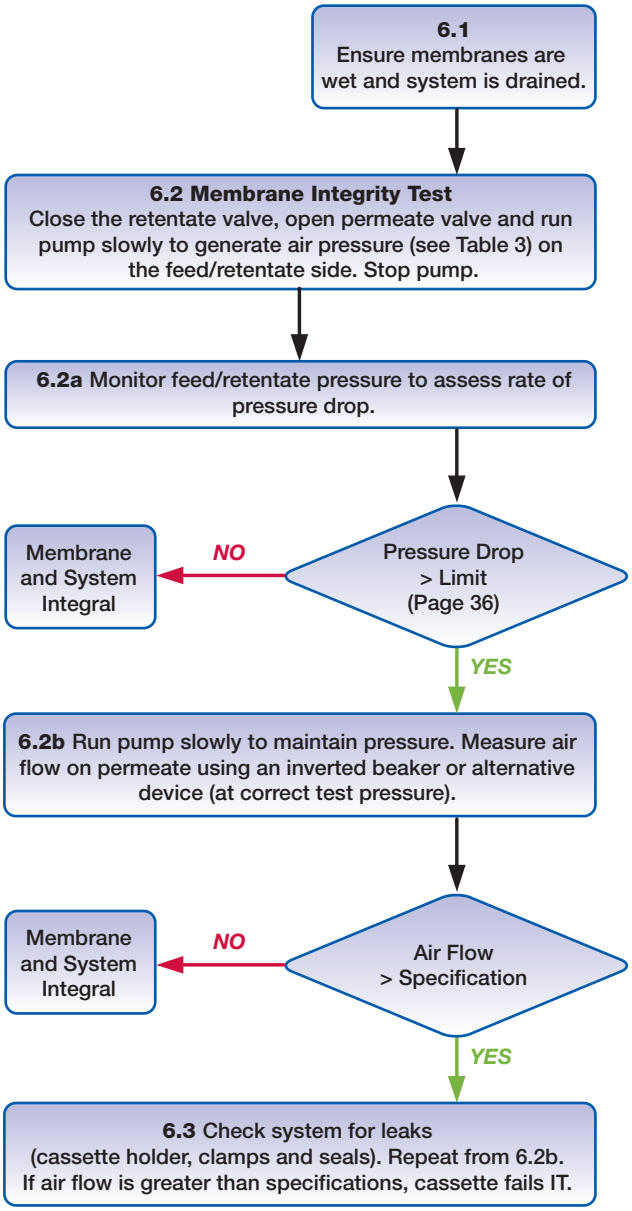
Temperature Correction Factor = 1.109 (Correcting the water temperature from 16 °C to 20 °C)

Normalized Water Permeability ($NWP_{20\,°C}$) = 75 x 1.109

= 83.17 LMH/barg

Step 6. Integrity Testing

Figure 25
Integrity Testing Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Before performing air flow integrity tests (IT), the membrane cassettes must be completely wetted out. Typically IT follows flushing and NWP, so the cassettes should be fully wetted.

These procedures assume a positive displacement pump (e.g., peristaltic or diaphragm) is used to generate air pressure. Refer to T-Series Membrane Cassette Care and Use Procedures (USD 2433b and 2662) for more detailed protocol.

Figure 26

Membrane Integrity Test – Generating Air Pressure (6.2)

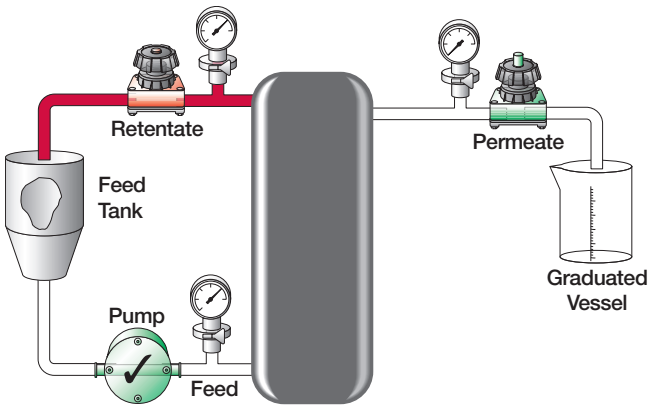


Figure 27

Membrane Integrity Test – Monitoring Air Pressure (6.2a)

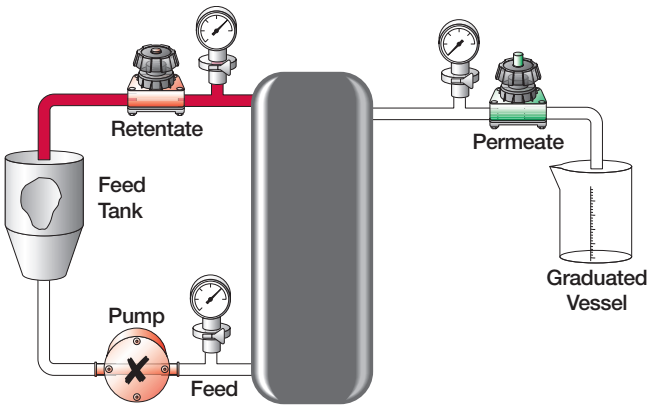
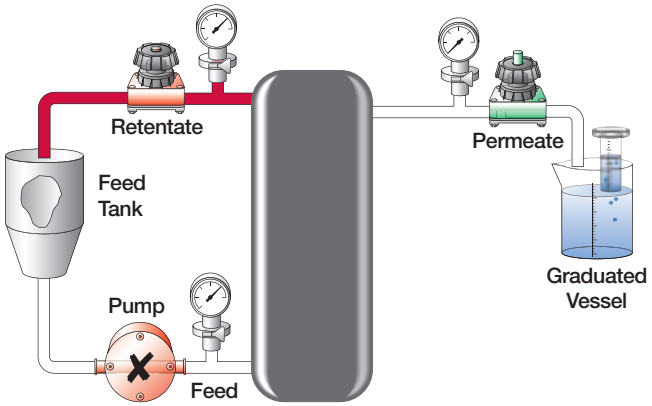


Figure 28

Measuring Air Flow with Inverted Beaker (6.2b)



Limit (guideline) for pressure drop: 200 mbarg/min or 3 psig/min. (Note: this is a guideline only. Direct measurement of diffusive flow should be used where necessary.)

Table 3

Recommended Air Flow Test Pressure and Specifications

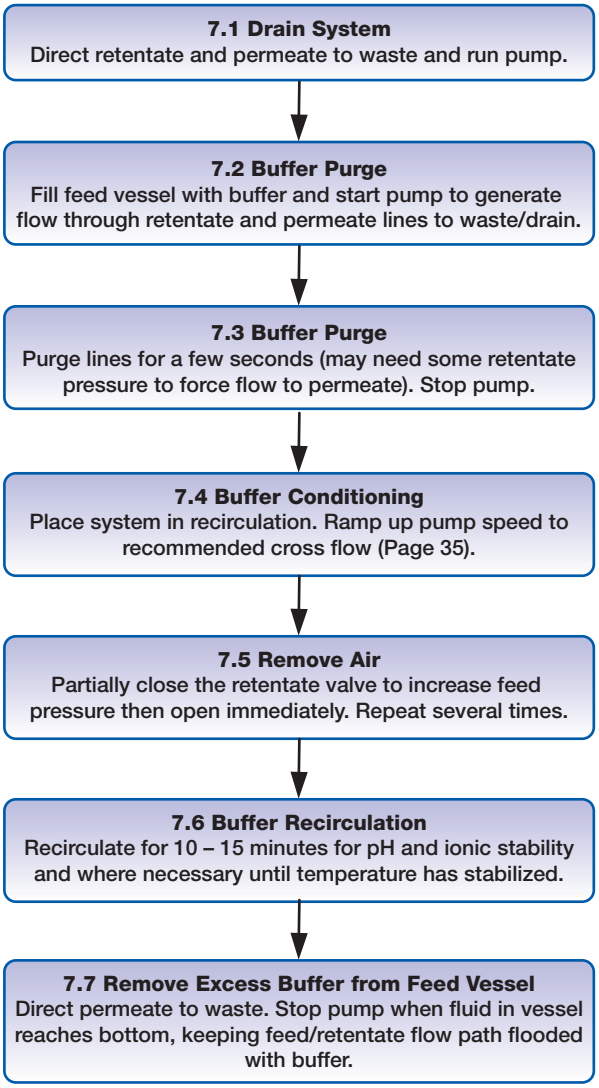
Membrane NMWC*	Test Pressure	Allowable Air Forward Flow Rate per Unit of Membrane
≤ 300 kD	2.0 barg (30 psig)	< 1600 sccm/m^2 (< 150 sccm/ft^2)

**Nominal Molecular Weight Cutoff*

Step 7. Buffer Conditioning

Figure 29

Buffer Conditioning Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Ensure you use a large enough volume to enable an initial purge to waste followed by recirculation.

Buffer conditioning removes trapped air from the filter and system and establishes conditions for pH, ionic strength and temperature to match the process sample.

It is important to know the system hold-up volume when calculating concentration factors, because this volume of buffer will dilute the product slightly when product is added to the feed vessel. (See Step 2.)

In Figure 29, buffer is shown as water. In a real process this will be the buffer the product is in at the start of the process.

Figure 30

Drain to Waste via Pump (Step 7.1)

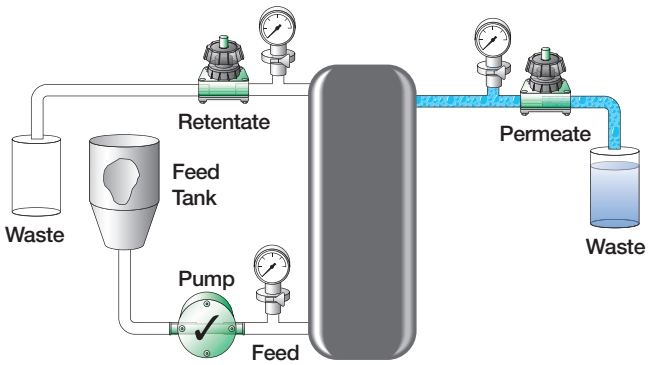


Figure 31

Retentate and Permeate to Waste (Step 7.2)

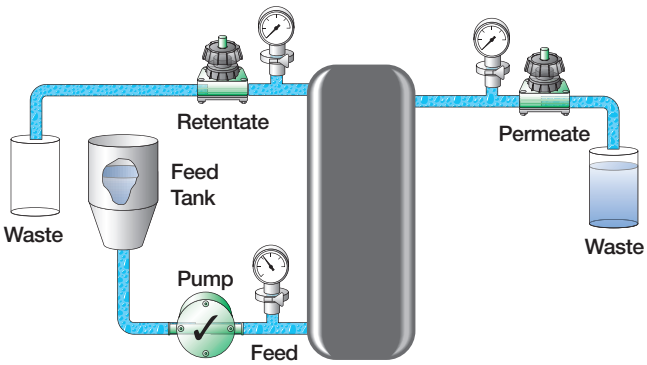


Figure 32

Recirculate with Pressure (Steps 7.4 and 7.5)

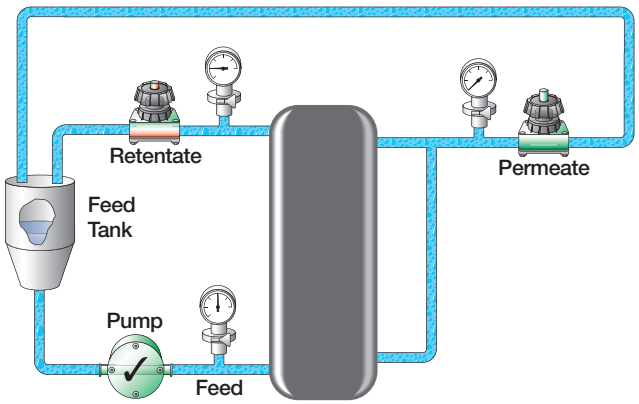
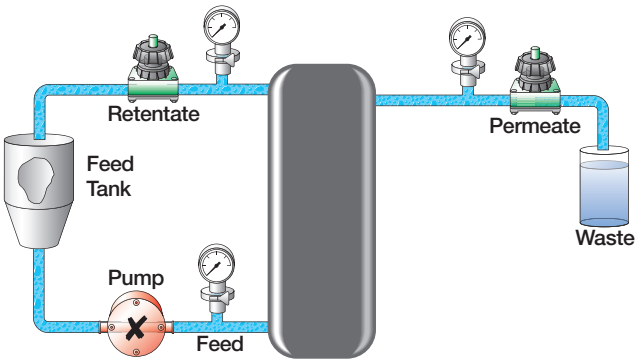


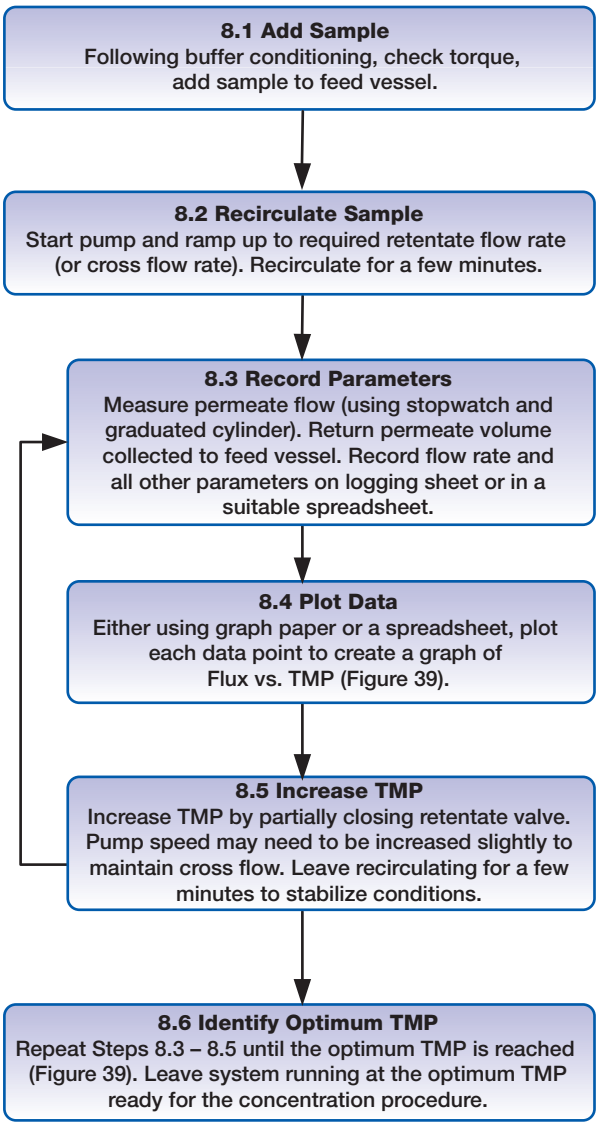
Figure 33

End of Buffer Conditioning (Step 7.7)



Step 8. Optimization

Figure 34
Optimization Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Hold-up volume, minimum working volume and pump speed settings for process and CIP should already have been determined during the earlier flushing steps. See Steps 2 and 3.

Optimum TMP

The optimum TMP for a given process is determined from the plot of permeate flux vs. transmembrane pressure. For UF it is typically the pressure at which the curve begins to plateau or level out (see example in Figure 39). In some cases transmission of a solute may also be a requirement, and in these cases a high TMP is generally not the optimum condition.

Figure 35

Add Product Sample to Feed Vessel (Step 8.1)

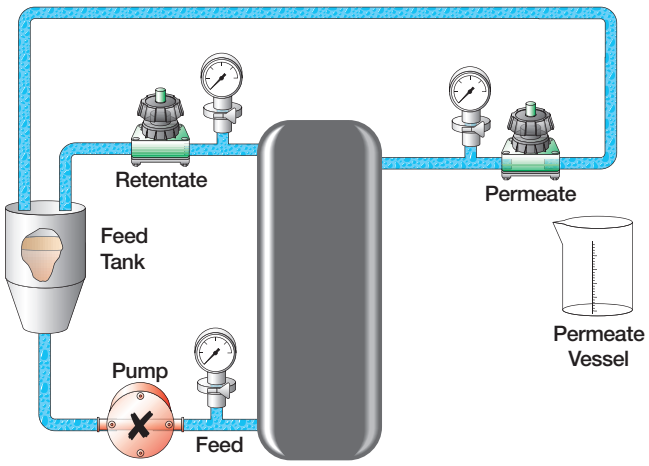


Figure 36

Recirculate Sample to Stabilize Conditions (Step 8.2)

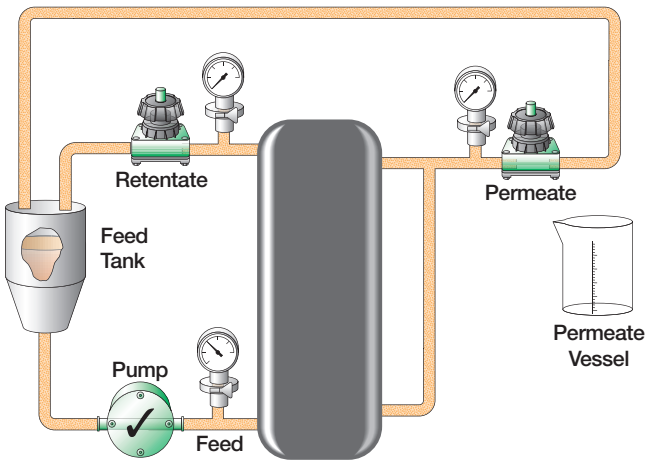


Figure 37

Measuring Permeate Flow Rate (Step 8.3)

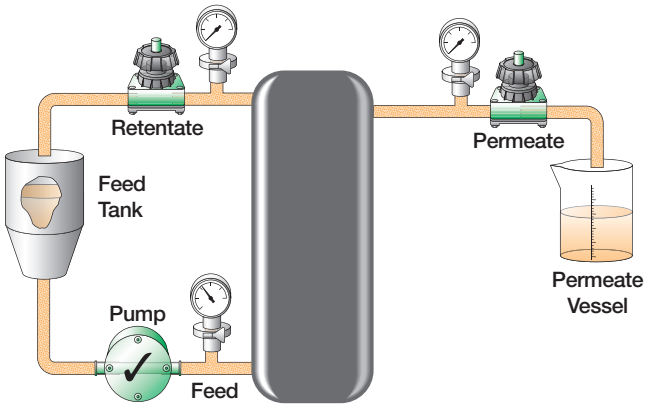


Figure 38

Increasing TMP by Partially Closing Retentate Valve (Step 8.5)

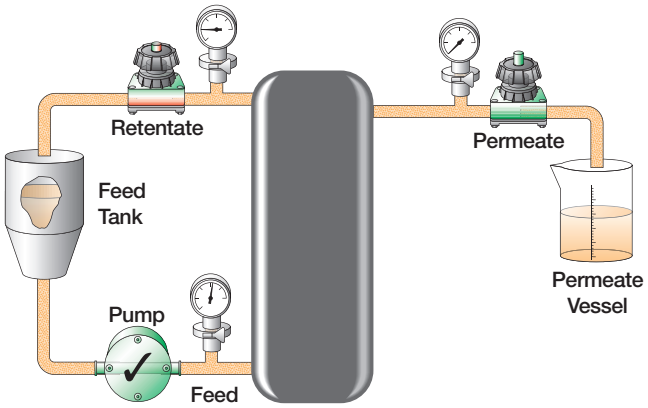
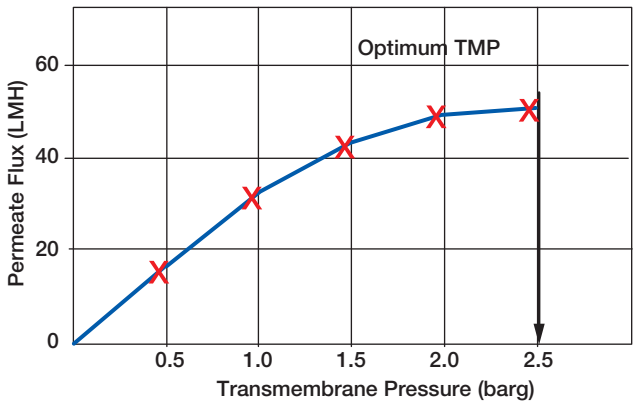


Figure 39

Example of Optimization – Plotting Flux vs. TMP



Equations

TMP = ([P_F + P_R]/2) - P_P

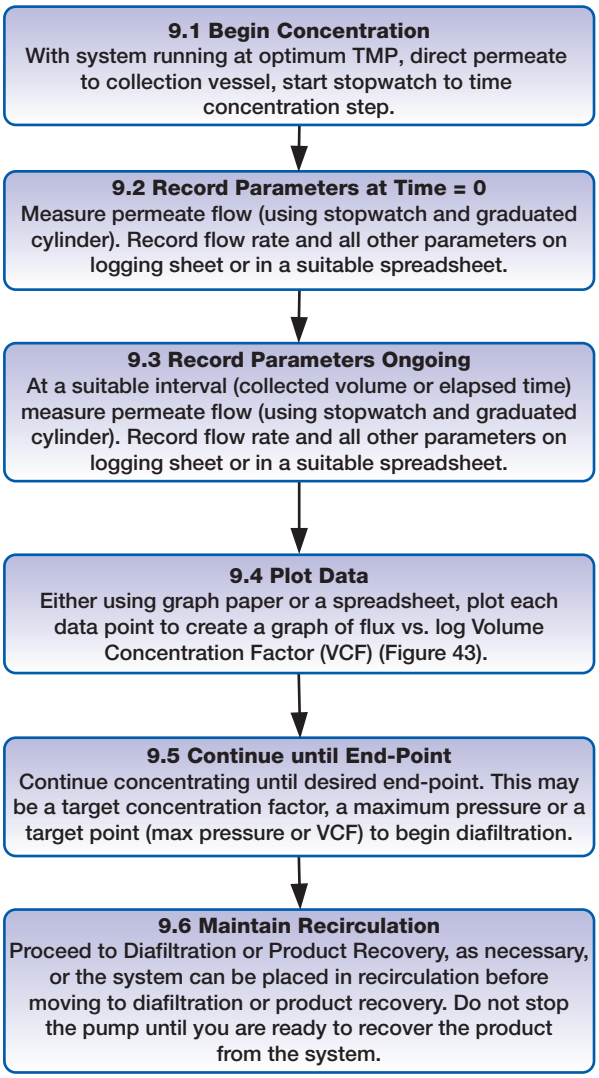
To convert mL/min/ft² to LMH:
mL/min/ft² x 0.6456 = LMH

Conversion

1 barg = 14.5 psig

Step 9. Concentration

Figure 40
Concentration Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

It is recommended that target concentration factor is exceeded to allow for pooling of product recovery samples to achieve maximum recovery and target concentration factors.

During concentration, the system can always be placed in recirculation mode as a safety condition if necessary. If this is done, the stopwatch should be paused until concentration is re-started.

During concentration it is normal for the process flux to gradually decrease with increasing concentration factor. If cross flow is maintained throughout, pressures are also likely to increase. The plot of flux vs. log VCF should be a straight line.

Figure 41

Concentration Configuration (Step 9.1)

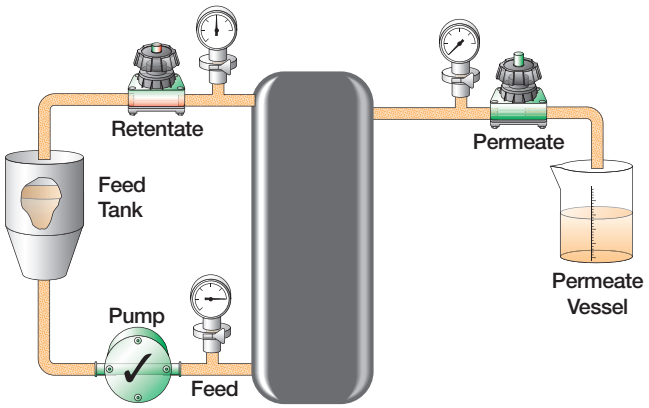


Figure 42

Recirculate at Target End-point (Steps 9.5 and 9.6)

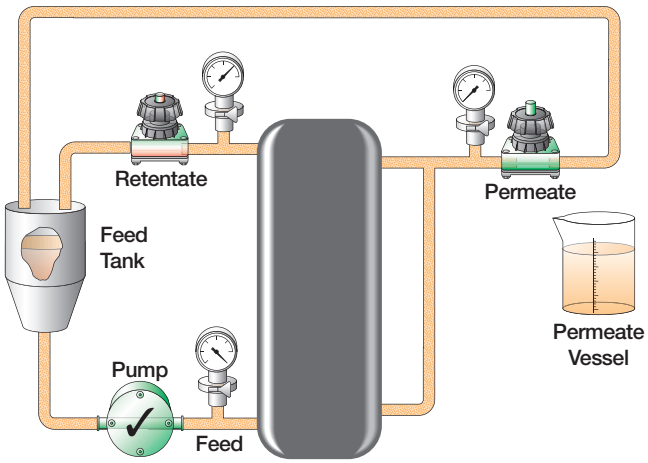
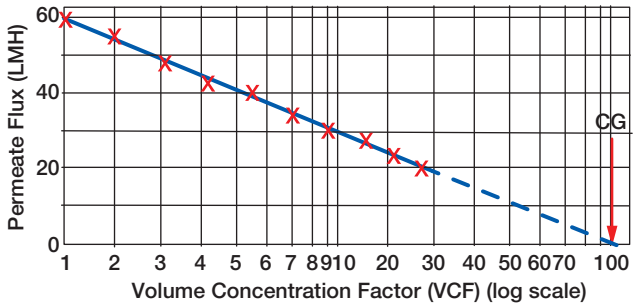


Figure 43

Example of Concentration Plot – Plotting Flux vs. VCF



C_G = Gel Layer Concentration

C_D = Diafiltration Concentration (Optimum)

$$C_D = \frac{C_G}{e^{1.0}}$$

$C_D = 0.368 \times C_G$

Equations for Concentration Factor and Product Concentration

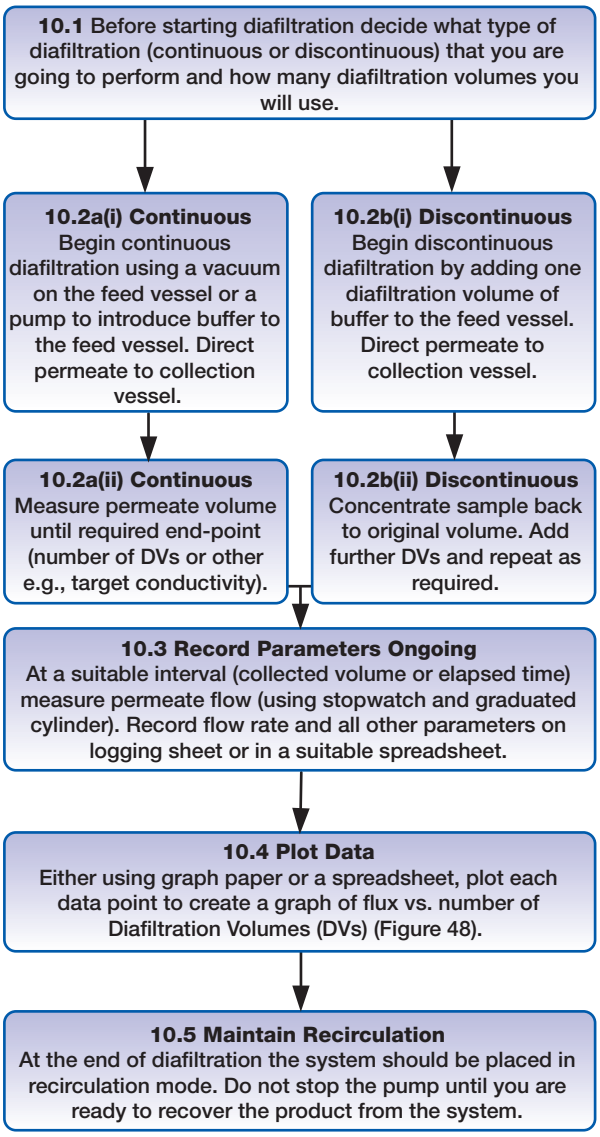
$$\text{Initial Sample Concentration} = \frac{\text{Sample Volume}}{\text{Sample Volume + Hold-up Volume}}$$

$$\text{Volume Concentration Factor (VCF)} = \frac{\text{Total Initial Volume (Sample + Hold-up)}}{\text{Total Initial Volume - Permeate Volume Collected}}$$

Actual (theoretical) Product Concentration = Initial Sample Concentration x VCF

Step 10. Diafiltration

Figure 44
Diafiltration Flow Diagram



Diafiltration Volume (DV)
One diafiltration volume (DV) is equal to the total volume on the upstream side prior to diafiltration.

Continuous Diafiltration
Diafiltration buffer is drawn into the feed vessel by vacuum created as permeate is removed from the system or added using a transfer pump matched to the permeate flow rate.

Discontinuous Diafiltration
One diafiltration volume of buffer is added to the feed vessel (sample is diluted) and the total volume is then re-concentrated back to the initial volume. This is repeated several times, until the desired end point is reached.

Figure 45

Continuous Diafiltration (Step 10.2a)

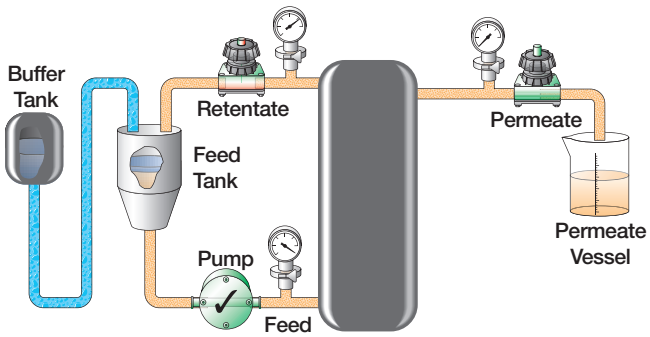


Figure 46

Discontinuous Diafiltration, Adding 1 DV (Step 10.2b)

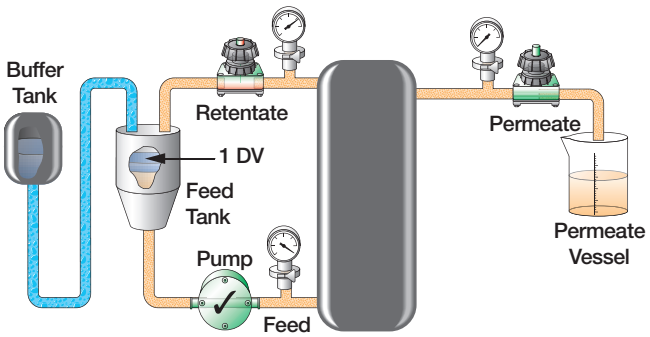
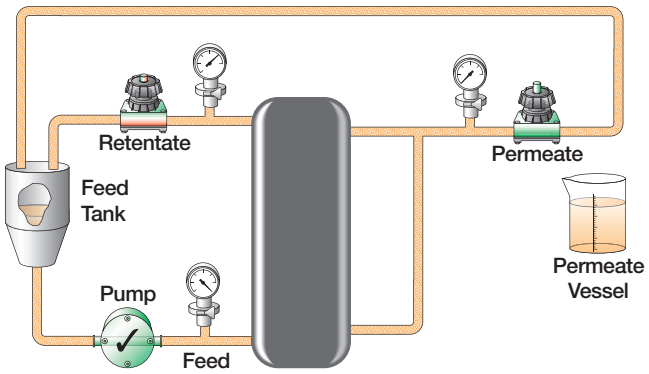


Figure 47

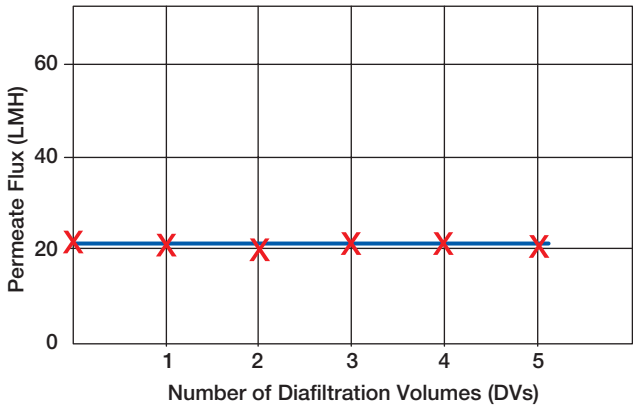
Recirculate at Target End-point (Step 10.5)



Note: Some form of mixing in the feed vessel will typically be required during diafiltration to ensure the added buffer mixes thoroughly with the product.

Figure 48

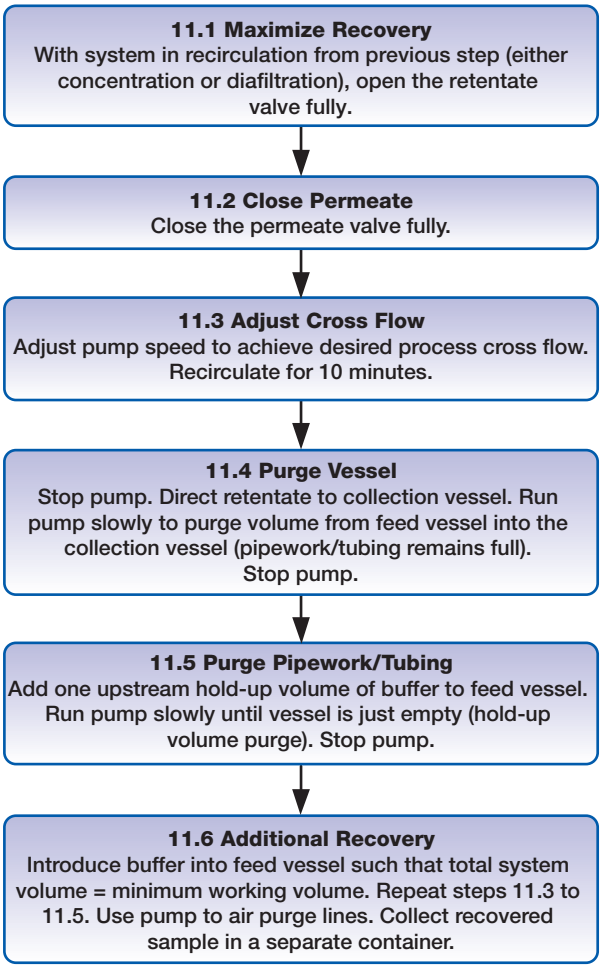
Example of Diafiltration – Plotting Flux vs. DVs



Step 11. Product Recovery

Figure 49

Product Recovery Flow Diagram



The procedure shown is an example only. Product recovery should be optimized for each process.

To maximize product yield at the desired final concentration, it is recommended that target concentration factor is exceeded to allow for pooling of product recovery samples to achieve maximum recovery and target concentration factors.

Figure 50

Recirculation with Screen Channel Cassettes (Step 11.3)

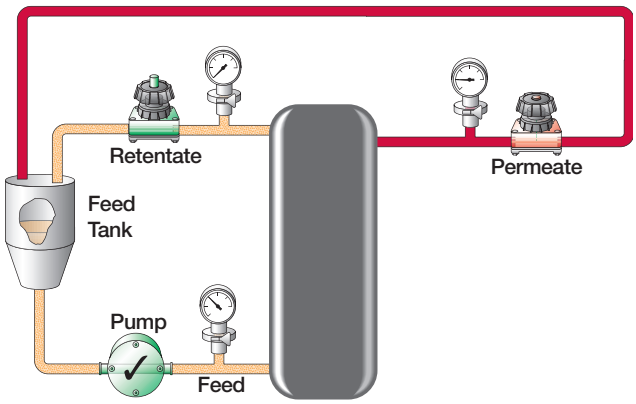


Figure 51

Purge Vessel (Step 11.4)

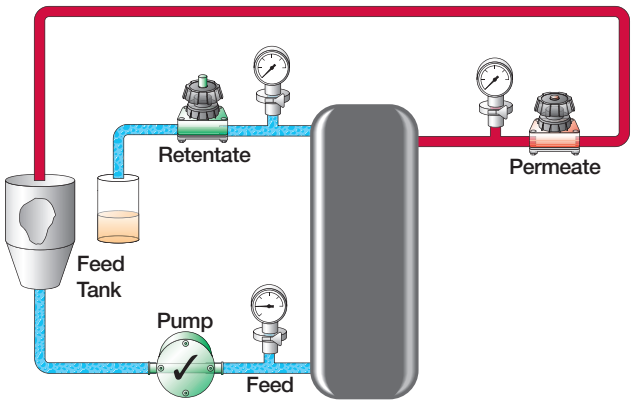


Figure 52

Purge Pipework/Tubing (Step 11.5)

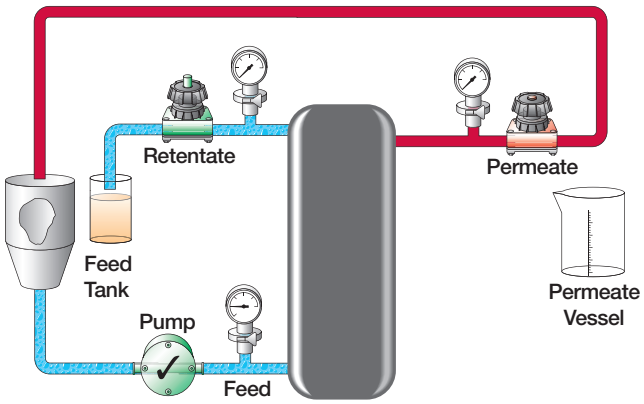
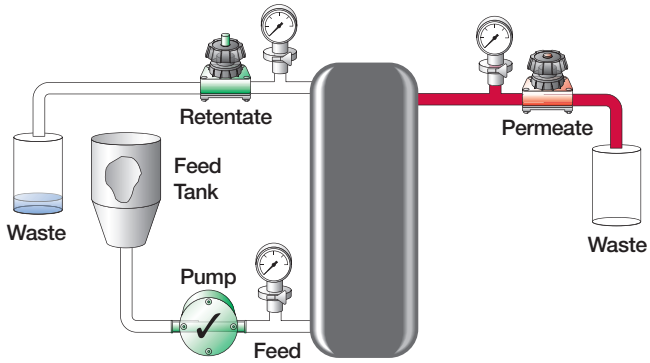


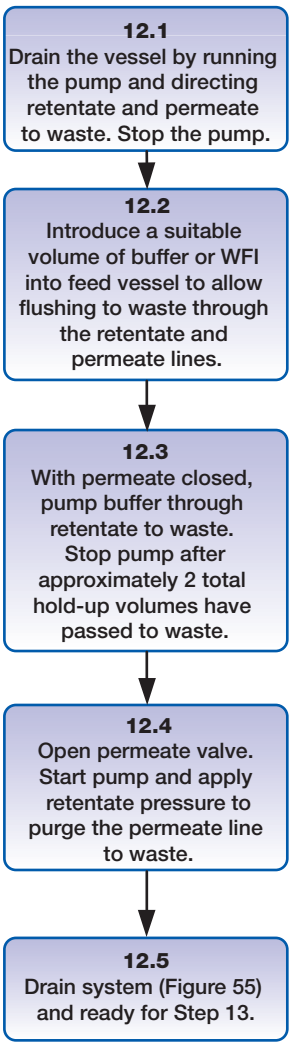
Figure 53

Additional Recovery, Blow Out Feed/Retentate Line (Step 11.6)



Step 12. Buffer Flush

Figure 54
Buffer Flush Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Buffer flush is recommended to remove foulants that can be easily washed out prior to introducing chemicals. Alternatively, users can go straight to Step 13, CIP.

Recirculation times and volumes are application specific. These must be validated.

Figure 55

Drain via Pump, Retentate and Permeate to Waste (Step 12.1)

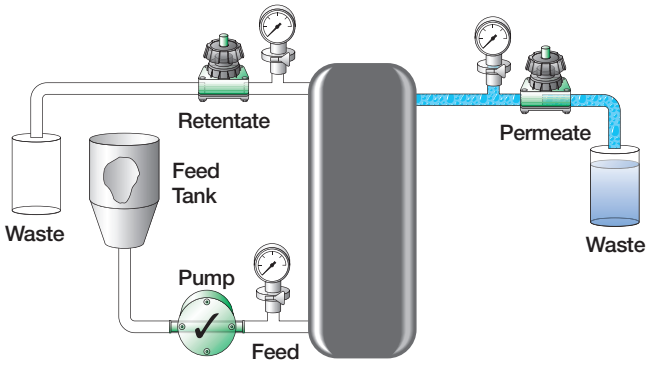


Figure 56

Retentate and Permeate to Waste (Step 12.2)

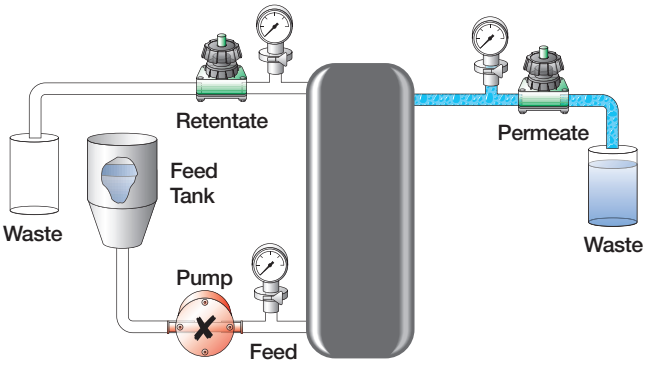


Figure 57

Retentate to Waste Permeate Closed (Step 12.3)

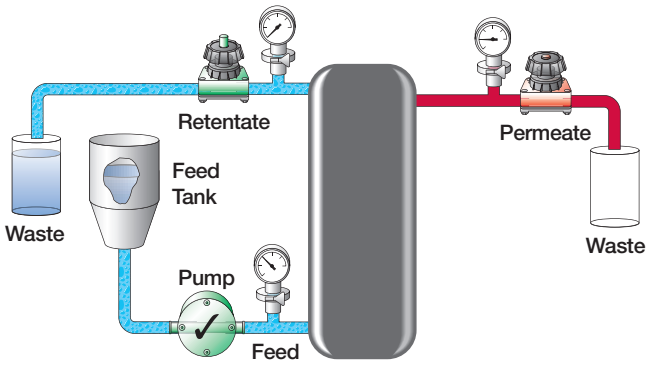
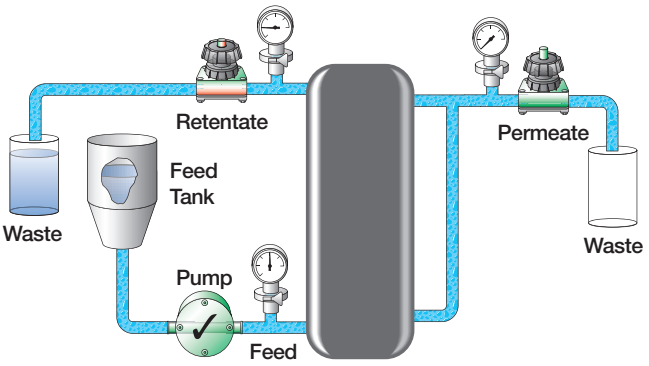


Figure 58

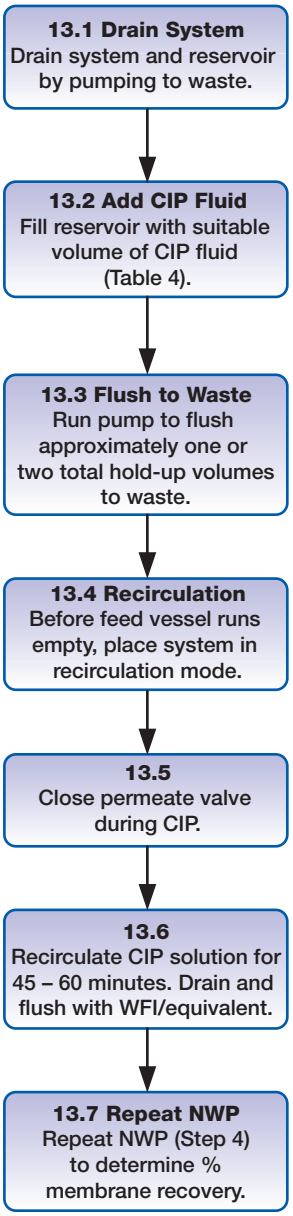
Permeate Flush to Waste under Pressure (Step 12.4)



Step 13. Clean in Place (CIP)

Figure 59

Clean In Place (CIP) Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Ensure you use a large enough volume to enable an initial purge to waste followed by recirculation.

Recirculation times, volumes, sanitization agent, and temperature are application specific. These must be validated. Ensure you use a large enough volume to enable an initial purge to waste followed by recirculation.

CIP retentate flow rate should be 1.5 x process retentate flow rate.

If CIP solution looks dirty after only a few minutes, stop cleaning, and begin again at 13.1.

Permeate valve may be closed or open during cleaning. If more than one cleaning cycle, close during first cycle and then leave open.

Figure 60

Retentate and Permeate to Waste (Steps 13.1 and 13.3)

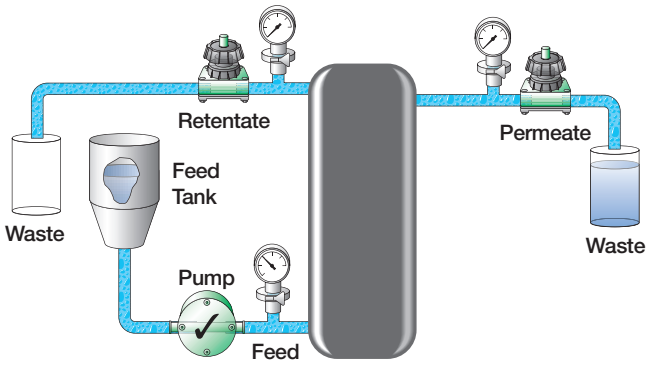


Figure 61

Recirculation with Permeate Open (Step 13.4)

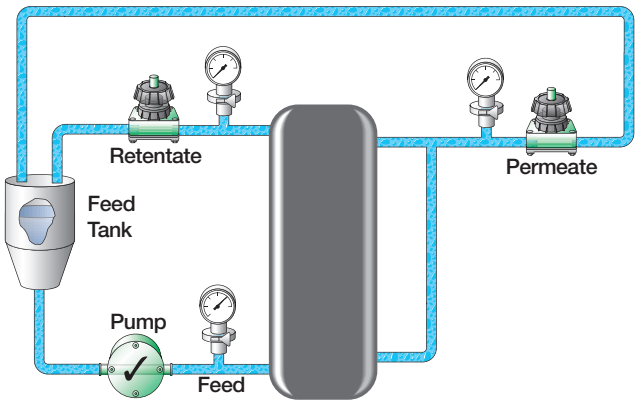


Figure 62

Recirculation with Permeate Closed (Step 13.5)

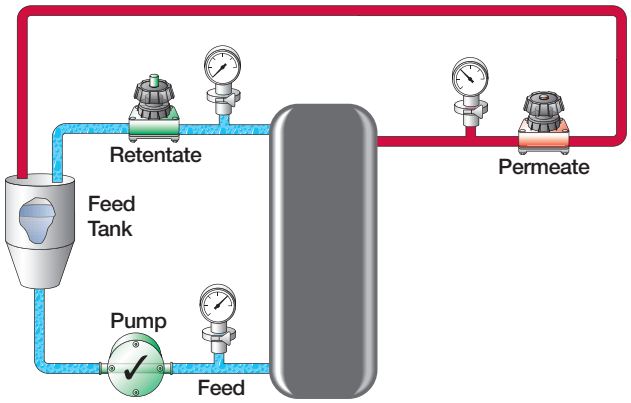


Figure 63

Recirculation with Permeate Open, Retentate Partially Closed (Step 13.5)

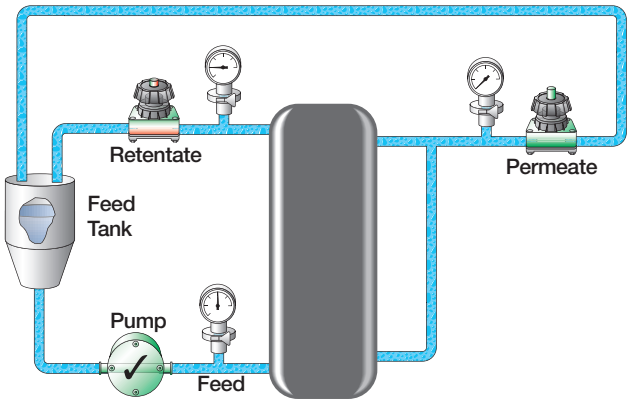


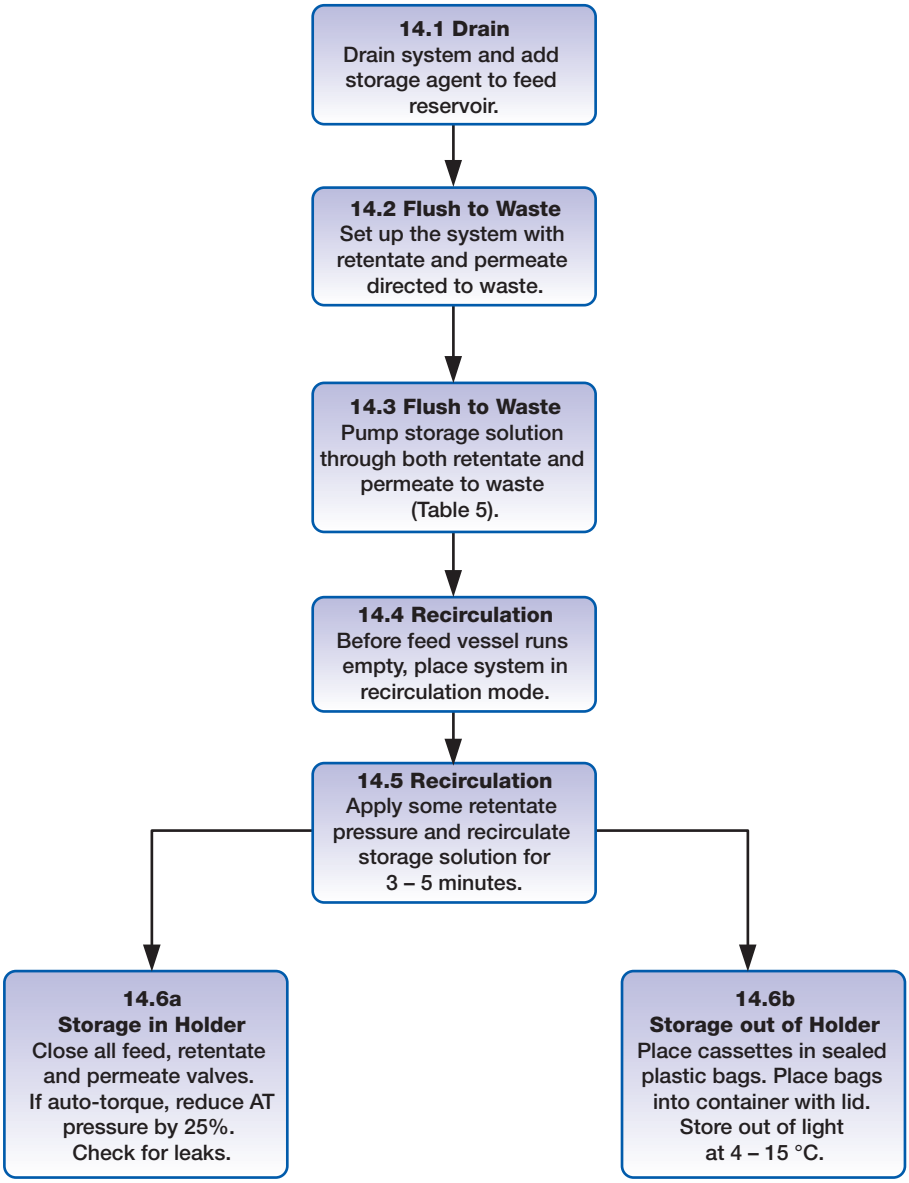
Table 4

Recommended CIP Solutions and Conditions

Membrane Type	Choose Suitable CIP Solution	Temperature
Omega	0.1 – 0.5 N NaOH	
	0.1 – 0.5 N NaOH + 200 – 400 ppm NaOCl	25 – 45 °C
Delta	0.1 N - 0.25 N NaOH	25 – 45 °C

Step 14. Storage

Figure 64
Storage Flow Diagram



Take appropriate safety measures to avoid injury or contact with fluids.

Ensure you use a large enough volume to enable an initial purge to waste followed by recirculation.
Recirculation times and volumes are application specific. These must be validated.
During recirculation, retentate flow rate should be 1.5 x process retentate flow rate.

Figure 65

Retentate and Permeate to Waste (Steps 14.2 and 14.3)

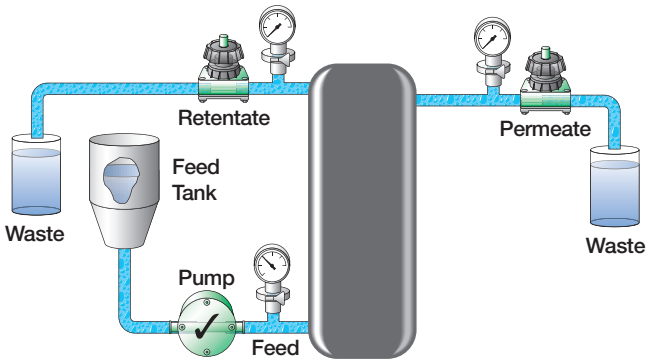


Figure 66

Recirculation with Pressure (Steps 14.4 and 14.5)

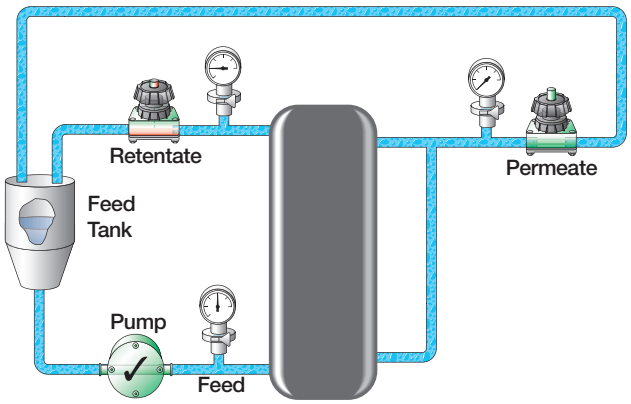


Table 5

Recommended storage agent for Pall membranes is 0.05 – 0.1 N NaOH. Cassettes may be stored for periods up to 1 year or longer. However, it is recommended that at 6 months storage, the pH of the storage solution be tested to determine if it is sufficiently caustic. Cassettes may be flushed with fresh storage solution at this time.

Recommended Storage Temperatures for Used Cassettes

Temperature	
4 – 15 °C	optimal
25 °C	maximum

Caution: Do not freeze.

Torque Recommendations

Periodically check the torque on each bolt for MT holders. The cassette will compress initially upon installation. Increasing the temperature of the feed solution will cause expansion of the cassettes, causing the clamping force to increase. Reduce torque accordingly if the system is to contain heated solution.

Table 6

Recommended Hydraulic Pressure Range for Pall AT Cassette Holders

Holder Type	Number of Hydraulic Pistons on Holder	Recommended Hydraulic Pressure Range for AT Cassette Holders	
		T-Series Cassettes with Omega or Delta Membrane	
		(barg)	(psig)
Centrasette LV AT	4	34 – 54	500 – 800
Centrasette 5 AT	4	34 – 54	500 – 800
Centrasette 10 AT	2	75 – 110	1100 – 1600
Centrastak™ AT	2/level	75 – 110	1100 – 1600

Table 7

Recommended Torque Values for Pall MT Cassette Holders

Holder Type	Number of Bolts on Holder	Recommended Torque Range for MT Cassette Holders[1]	
		T-Series Cassettes with Omega or Delta Membrane	
		(in-lb.)	(Nm)
Centramate LV	4	50 – 70	6 – 8
Centramate	4	70 – 90	8 – 10
Centrasette 5, Centrasette LV	4	350 – 550	40 – 60
Centrasette 10, Centrasette P	2	700 – 1100	80 – 120
Centrasette 10	4	350 – 550	40 – 60

[1] *Pall membrane cassettes*

Operating Specifications

Table 8 lists the recommended CFF rates for operating Pall Omega or Delta membrane cassettes.

CFF = retentate flow rate (L/min) / membrane area (m^2 or ft^2)

Table 8

Recommended Cross Flow Rates

Holder Type	Units	Minimum CFF Processing Mode	Recommended CFF[1] Processing Mode	Recommended CFF[1] Cleaning Mode
		Screen Channel Cassettes	Screen Channel Cassettes	Screen Channel Cassettes
Centramate and	L/min/m^2	3	5 – 8	7 – 12
Centrasette	L/min/ft^2	0.3	0.5 – 0.8	0.7 – 1.2

[1] *Trials must be performed to determine the most effective cross flow rate to use for any specific application.*

Table 9 gives the operating limits for pressure, temperature and pH. Exceeding any of these limits may cause permanent damage to the cassette and pose a safety hazard for the operator.

Table 9a

Cassette Operating Limits of Pressure, Temperature, and pH for T-Series Cassettes with Omega Membranes (All Formats)

Maximum Recommended Operating Pressure**	Maximum TMP	Temperature Range	pH Range
6 barg (87 psig) @ 23 °C 4 barg (58 psig) @ 55 °C	4 barg (58 psig) @ 55 °C	-5 to 55 °C	2 to 14 @ 4 barg (58 psig) @ 50 °C

*** Clamping pressure must be set to the recommended level to avoid leaks.*

Table 9b

Cassette Operating Limits of Pressure, Temperature, and pH for T-Series Cassettes with Delta Membranes (All Formats)

Maximum Recommended Operating Pressure**	Maximum TMP	Temperature Range	pH Range
6 barg (87 psig) @ 23 °C 4 barg (58 psig) @ 55 °C	4 barg (58 psig) @ 55 °C	4 to 55 °C	2 to 13 @ 4 barg (58 psig) @ 50 °C

*** Clamping pressure must be set to the recommended level to avoid leaks.*

Temperature Correction Factors

Table 10

Temperature Correction Factors (TCF) for Normalizing Water Permeability

Temperature Correction Factors ($TCF_{20\ °C}$)			
T °C	$TCF_{20\ °C}$	T °C	$TCF_{20\ °C}$
4	1.57	28	0.83
5	1.52	29	0.81
6	1.47	30	0.80
7	1.43	31	0.78
8	1.39	32	0.76
9	1.35	33	0.75
10	1.31	34	0.73
11	1.27	35	0.72
12	1.24	36	0.70
13	1.20	37	0.69
14	1.17	38	0.68
15	1.14	39	0.66
16	1.11	40	0.65
17	1.08	41	0.64
18	1.05	42	0.63
19	1.03	43	0.62
20	1.00	44	0.61
21	0.98	45	0.60
22	0.95	46	0.59
23	0.93	47	0.58
24	0.91	48	0.57
25	0.89	49	0.56
26	0.87	50	0.55
27	0.85		

Diafiltration — Continuous vs. Discontinuous

Table 11

Continuous vs. Discontinuous Diafiltration Table

Percent Transmission (passage) of a Salt	Continuous Diafiltration		Discontinuous Diafiltration	
	Solute Removal	Number of DVs	Solute Removal	Number of DVs
100% Passage	63.21	1	50.00	1
	86.27	2	75.00	2
	95.02	3	87.50	3
	98.17	4	93.75	4
	99.33	5	96.88	5
80% Passage	55.07	1	42.57	1
	79.81	2	67.01	2
	90.93	3	81.05	3
	95.92	4	89.12	4
	98.17	5	93.75	5

Conversion Tables

Table 12

Conversion Tables

Area		Pressure		Flow		Volume	
ft^2 to m^2		psig to barg		m^3/hr to L/min		(U.S.) Gal to Liter	
0.1	0.0092	1	0.07	1	16.7	1	3.78
0.2	0.0186	10	0.7				
1	0.0929	30	2				
2	0.186						
5	0.46						
barg to psig		m^2 to ft^2		barg to kPa		m^3	Liter
1	14.5	1	10.76	1	100	1	1000

PALL Life Sciences

United States
800.717.7255 toll free (USA)
516.484.5400 phone
516.801.9548 fax
biopharm@pall.com E-mail

Europe
+41 (0)26 350 53 00 phone
+41 (0)26 350 53 53 fax
LifeSciences.EU@pall.com E-mail

Filtration. Separation. Solution.SM

UpScale ScaleUp

Pall has the most comprehensive family of scalable separation products.

Visit us on the Web at www.pall.com/biopharm

E-mail us at biopharm@pall.com

International Offices
Pall Corporation has offices and plants throughout the world in locations such as: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, France, Germany, India, Indonesia, Ireland, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Poland, Puerto Rico, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, the United States, and Venezuela. Distributors in all major industrial areas of the world.

The information provided in this literature was reviewed for accuracy at the time of publication. Product data may be subject to change without notice. For current information consult your local Pall distributor or contact Pall directly.

12/09, PDF, UK GN09.3100 USTR 2453b