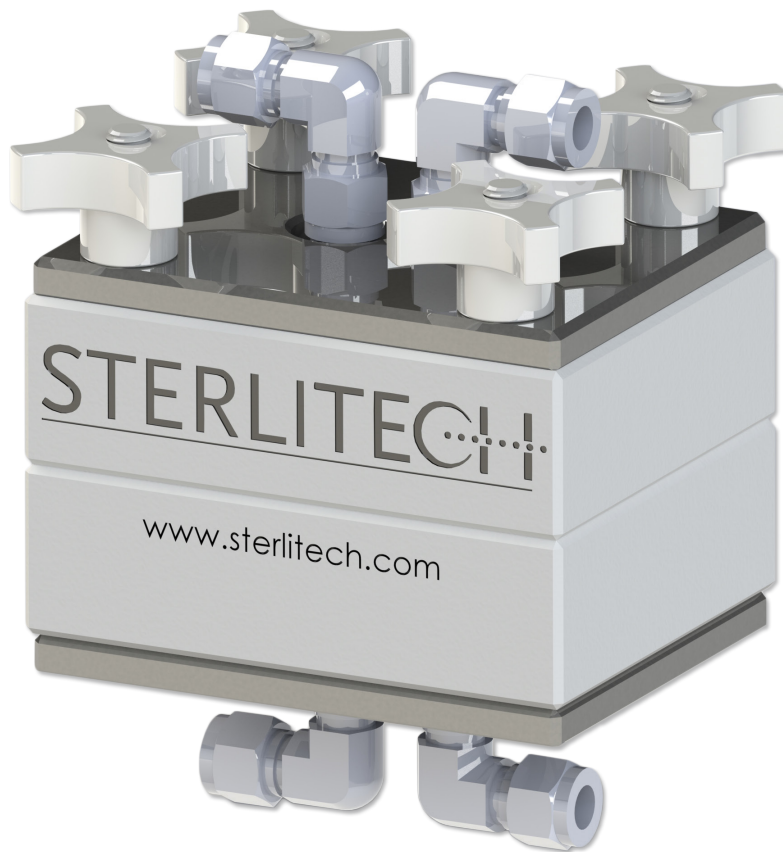


STERLITECH

C o r p o r a t i o n

CF016D-FO CELL ASSEMBLY & OPERATION MANUAL



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1. INTRODUCTION

The CF016D-FO Cell is a laboratory-scale filtration unit that is designed to evaluate a variety of engineered osmosis processes, including Forward Osmosis (FO), and Pressure Retarded Osmosis (PRO). It simulates the flow dynamics of larger, commercially available membrane elements such as industrial spiral wound membrane elements. Users can vary the operating conditions and fluid dynamics over broad ranges.

Table 1 outlines the operational parameters and technical specifications of the CF016D-FO Cell. *Prior to operating or servicing this device, this manual must be read and understood.*

Table 1: CF016D-FO Features and Technical Specification

Parameter	Description
Membrane Active Area	20.6 cm ² (3.2-inch ²)
Hold up Volume	13 ml (0.44 oz)
CF016D-FO	Delrin
Maximum Pressure	69 bar (1000 psig)
Maximum Temperature	82 °C (180 °F)
O-rings	Buna* (Other materials available)
pH Range	Membrane Dependent
Cross Flow Velocity	Variable
Dimensions	
Slot Depth	2.28 mm (0.09 inches)
Slot Width	39 mm (1.54 inches)

2. CF016D-FO CELL COMPONENTS

The cell body consists of the tightening screws, cell top, membrane filter, O-rings, and cell bottom. **Figure 1** (see *page 2*) illustrates a typical assembly of the CF016D-FO. The CF016D-FO is also packaged with a length of permeate tubing and membrane cutting template.

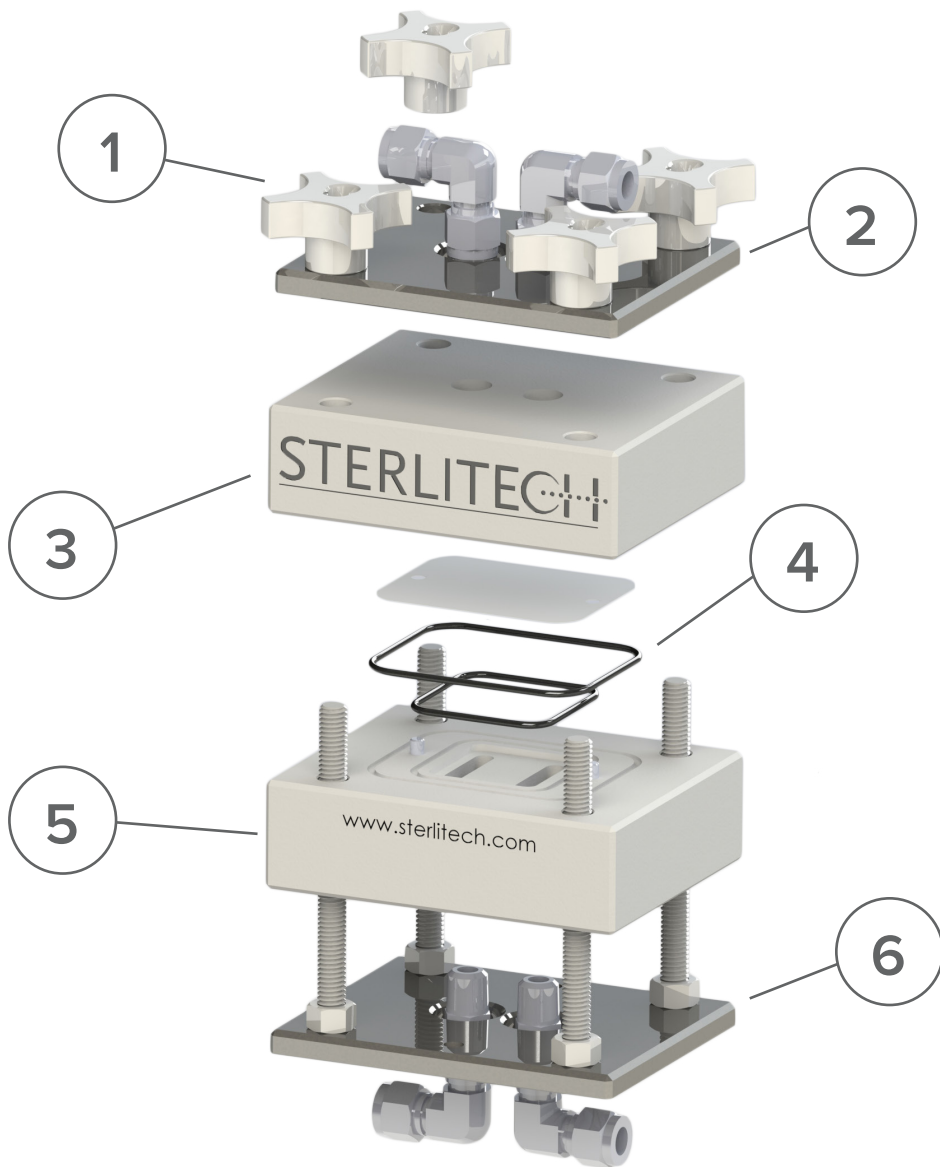
2.1 ADDITIONAL EQUIPMENT

The CF016D-FO cell also requires additional equipment to operate that are sold separately:

- Feed Pump
- Feed Tank
- Draw Solution Pump
- Draw Solution Tank
- Filtration membrane packs

3. CF016D-FO CELL ASSEMBLY

Figure 1: CF016D-FO Cell Body Assembly



Legend:

- 1. Tightening Knobs
- 2. Top Plate
- 3. Cell Top
- 4. O-Rings
- 5. Cell Bottom
- 6. Bottom Plate

After verifying that all of the necessary components were shipped and present, you can begin the assembly of the cell.

To assemble the CF016D-FO Cell:

1. Wet the O-rings with a small amount of water or the fluid to be processed and install them into the grooves on the cell bottom.

Caution: *Make sure that the O-rings lie flat in the grooves of the cell bottom. Leaking may occur if the O-rings do not lie flat in the grooves. The O-rings will be cut or crushed when the system is operating if the O-rings are not installed correctly.*

2. Place a piece of pre-cut membrane on to the cell bottom using the two alignment pins to hold the membrane in position. The membrane should be installed with the shiny or active side down facing the feed solution (bottom) in an FO process and facing the draw solution (top) in a PRO process.

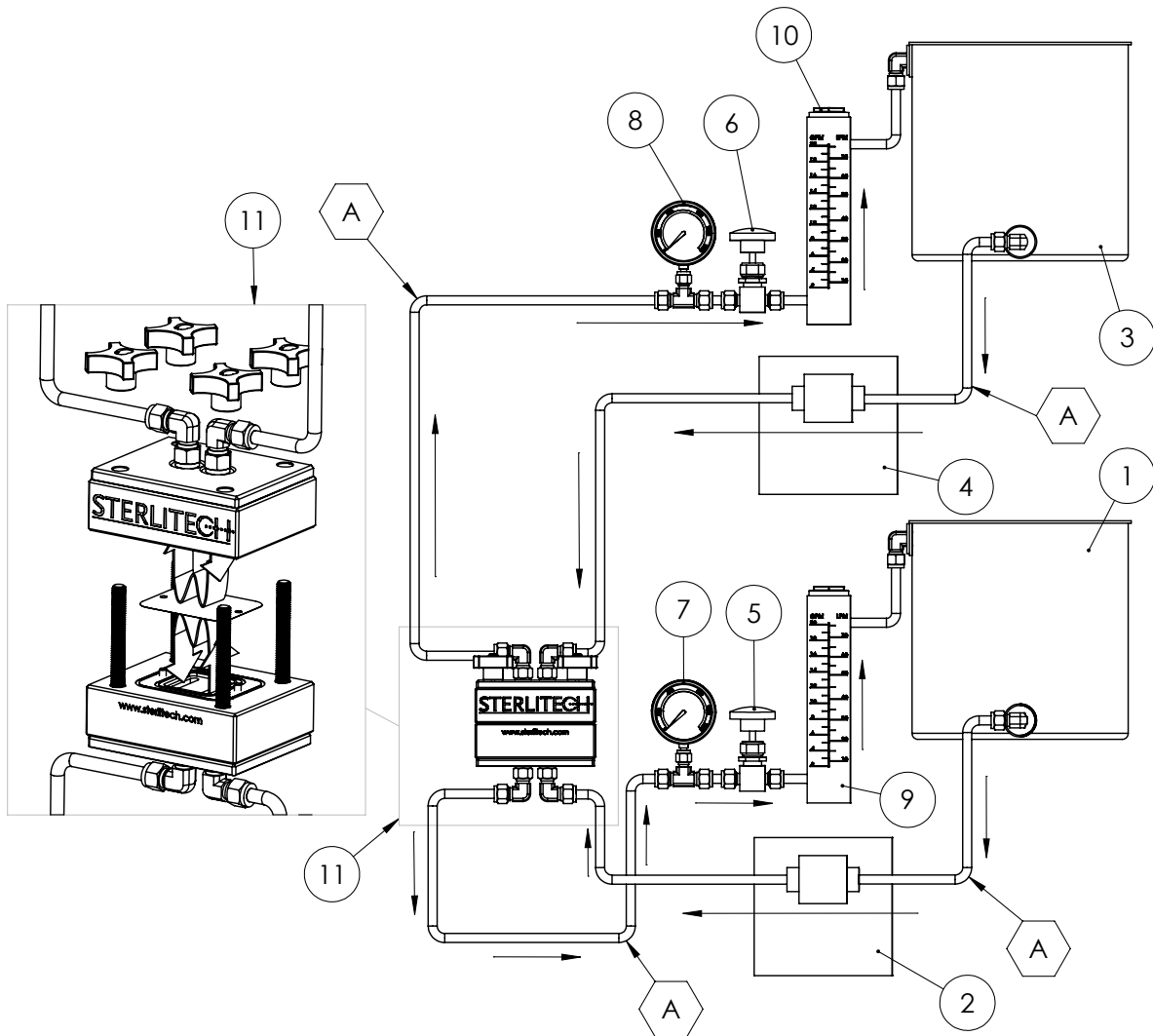
Note: *If you are cutting your own membranes, the membrane's outer edge should fit between the inner and outer O-rings in the cell body to prevent leakage.*

3. Place the cell top plate by aligning the two pins on the sides of the cell.
4. Secure the cell top by inserting and tightening the provided tightening knobs into each of the corner holes.

The CF016D-FO Cell is now assembled and ready to be connected to a feed pump for operation.

4. CF016D-FO CELL CONNECTIONS AND PARTS

Figure 2: Example CF016D-FO Flow Diagram



CF016P/ CF016D FO FLOW DIAGRAM	
Item No.	Part Description
1	Feed Tank
2	Feed Pump
3	Draw Solution Tank
4	Draw Solution Pump
5	Concentrate Pressure Control Valve
6	Draw Solution Pressure Control Valve
7	Concentrate Pressure Gauge
8	Draw Solution Pressure Gauge
9	Concentrate Flow Meter
10	Draw Solution Flow Meter
11	CF016-FO Cell Assembly
A	3/8" Low Pressure Tubing



Figure 2 shows typical plumbing connections that need to be made for the operation of the CF016D-FO Cell; the configuration can change slightly depending on the objectives of the user. In general, the connections to be made are:

1. Feed tank to the feed pump
2. Pump outlet to the feed inlet of the cell body
3. Feed outlet of the cell body to the concentrate collection tank/feed tank
4. Draw solution tank to the draw solution pump
5. Draw solution pump outlet to the draw solution inlet of the cell body
6. Draw solution outlet of the cell body to the draw solution collection/draw tank

Figure 2 also lists the additional components that are necessary to operate the CF016D-FO cell. These components are sold separately and can be found in the Membrane/ Process Development section of the Sterlitech website (<http://www.sterlitech.com/membrane-processdevelopment.html>). The final assembly of the forward osmosis system will vary with the feed vessels, pumps, and tubing used.

5. OPERATION OF THE CF016D-FO CELL

Once the CF016D-FO Cell has been assembled and connected to a feed system, it can be used in variety of applications that includes forward osmosis and pressure retarded osmosis.

To operate the CF016D-FO Cell:

1. Open all of the valves in the system to relieve any pressure build-up before turning on the feed pump.
2. Turn the feed and draw solution pump on.
3. Adjust the control valves (sold separately) to obtain the desired pressure and flow for feed and draw solution.

Note: *Experimentation enables you to determine the optimum settings for pressure, flow rate, and shim/spacer combination to use on the chosen membrane and the fluid being processed.*

4. Once the experiment is complete, shut down the system by turning the feed and draw solution pumps off and opening all of the valves to relieve any pressure build up.

To replace a membrane filter:

1. Turn the feed and draw solution pump OFF.
2. Open all of the valves in the system to relieve any pressure build up.
3. Loosen the screws in the cell top.
4. Separate the cell body top from the cell bottom.
5. Remove the membrane.
6. Install the new membrane.
7. Reassemble the cell top and bottom.
8. Secure the cell top to the cell bottom using the tightening knobs.
9. Turn the feed and draw solution pump on.

6. SUPPLEMENTARY OPERATING INFORMATION

6.1 MEMBRANE PERFORMANCE

Parameters such as viscosity, pressure, and suspended solids may also affect performance/operation. Experimentation with the CF016D-FO Cell can help predict the best operating parameters. If your pump is delivering too much flow, a portion of the flow can be diverted back to the feed container before entering the feed inlet of the cell body. This requires installation of an optional bypass valve and fitting on the pump outlet, which is not supplied with the system.

6.2 TEMPERATURE LIMITS

The membranes, feed spacer, permeate, O-rings, and cell body materials construction dictate the maximum operating temperatures.

Table 2: Upper Temperature Limits

Component	Maximum Temperature
CF016D-FO Cell	82 °C (180 °F)
Membrane Elements	Variable
O-rings	
Viton	200° C (400° F)
EPDM	150° C (300° F)
Buna-N	121° C (250° F)

7. ACCESSORY AND SPARE PART ORDERING INFORMATION

Accessories and spare parts for the CF016D-FO Cell can be ordered by calling Sterlitech Corporation at 1-877-544-4420 or by visiting www.sterlitech.com.

Table 3: Accessory and Spare Part Ordering Information

Product	Shipping Weight	Ordering Number
CF016D-FO Cell, for operation to 69 bar (1000 psig)		CF016D-FO
Feed Flow Pump	Contact Sterlitech	Contact Sterlitech
Draw Solution Pump	Contact Sterlitech	Contact Sterlitech
Accessories		
Feed Spacer Assortment Pack 17, 31, 47, and 65 mil¹	0.5 kg (1 lb)	1142820
CF016 Steel Rule Die		1230116
Stainless Steel Stand	3.1 kg (6.8 lbs)	1230031
Modified Osmosis Insert²		1230038
Spare Parts		
EPDM O-rings	28 g (1 oz)	CF-EPDM016
Viton O-rings	28 g (1 oz)	CF-Viton016
Buna O-rings	28 g (1 oz)	CF-Buna016
Back Pressure Control Valve, 0-400 psi³	0.9 kg (2 lbs)	1149428
CF016 Filter Support (Sintered Metal)		1230119
Membrane Packs	Contact Sterlitech	Contact Sterlitech

¹Other sizes are available. Contact Sterlitech Corporation for more information.

²Modified Osmosis Insert is an accessory (sold separately) that is designed for experiments where a differential pressure is applied to the membrane sides, such as in a pressure-retarded osmosis (PRO) process or an assisted FO.

³Other pressure ranges available.

8. RETURN MATERIAL AUTHORIZATION

If materials are to be returned to Sterlitech for repair, evaluation, or warranty consideration, a Return Material Authorization (RMA) number and form must be obtained from Sterlitech prior to the return. Contact Sterlitech's Customer Service Department for these forms.

The form must be completed and returned with the material. Be sure to include a complete, detailed written reason for the return. Also, include serial numbers, installation and removal dates, and any other pertinent information that is available. CF016D-FO Cells have a serial number imprinted on the cell bottom.

Indicate the proposed disposition of the material, and reference the RMA number on all packages or cartons. All material must be shipped to Sterlitech with freight prepared by the customer.

9. WARRANTY

The following is made in lieu of all other warranties expressed or implied. Sterlitech Corporation guarantees equipment to be free from defects in material and workmanship when operated in accordance with written instructions for a period of one year from receipt. Parts not manufactured by Sterlitech are covered by their manufacturer's warranties, which are normally for one year.

Manufacturers and Seller's only obligation shall be to issue credit against the purchase or replacement of equipment proved to be defective in material or workmanship. Neither manufacturer nor seller shall be liable for any injury, loss or damage, direct or indirect, special or consequential, arising out of the use of, misuse, or the inability to use such product.

The information contained herein is based on technical data and tests, which we believe to be reliable, and is intended for use by persons having technical skill at their discretion and risk. Since conditions of use are outside Sterlitech's control, we can assume no liability whatsoever for results obtained or damages incurred through the application of the data presented.

This information is not intended as a license to operate under, or a recommendation to infringe upon, any patent of Sterlitech or others covering any material or use.

The foregoing may not be altered except by a written agreement signed by officers of the manufacturer.

10. TECHNICAL ASSISTANCE

Please contact us if you have any questions or technical inquiries about our products by calling Sterlitech Corporation at 1-877-544-4420 or by visiting www.sterlitech.com.

APPENDIX 1: CF016D-FO CELL APPLICATIONS

The following studies utilized the CF042 Cell in their method and are listed here to illustrate the potential applications for the CF016-FO. These studies are good references for understanding the operation of the CF016D-FO Cell.

APPLICATION	STUDY CITATION
Forward Osmosis and Low Pressure Reverse Osmosis	Yangali-Quintanilla, Victor, Zhenyu Li, et al. "Indirect desalination of Red Sea water with forward osmosis and low pressure reverse osmosis for water reuse."Desalination. 280. (2011): 160-166.
Ultrafiltration (Food Processing)	Post, Antonie, Hanna Sampels, et al. "A comparison of micellar casein and β -casein as sources of basic peptides through tryptic hydrolysis and their enrichment using two-stage ultrafiltration."International Journal of Dairy Technology. 65.4 (2012): 482-489.
Ultrafiltration and Nanofiltration (Protein Production)	Ranamukhaarachi, Sahan, Lena Meissner, et al. "Production of antioxidant soy protein hydrolysates by sequential ultrafiltration and nanofiltration."Journal of Membrane Science. 429. (2013): 81-87.
Membrane Development	Qadir, Ahmad. Development of new membranes for desalination pre-treatment. MA thesis. University of Illinois at Urbana-Champaign, 2011. Web. < https://www.ideals.illinois.edu/handle/2142/26369 >.

APPENDIX 2: STERLITECH BENCH SCALE FILTRATION PRODUCTS

	Discoverer	Innovator	Explorer	Developer	Investigator
					
	HP4750(X)	CF016	CF042	Sepa	1812
Filter Holder					
Membrane Active Area	14.6 cm ² (2.26 in ²)	20.6 cm ² (3.2 in ²)	42 cm ² (6.5 in ²)	140 cm ² (24 in ²)	0.27-0.46 m ² (3-5 ft ²)
Typical Permeate Flux	30-300 LMH (17.6-176 GFD)	30-300 LMH (17.6-176 GFD)	30-300 LMH (17.6-176 GFD)	30-300 LMH (17.6-176 GFD)	30-300 LMH (17.6-176 GFD)
Typical Permeate Flow Rate (per Cell)	1.5-15 mL/min	1-10 mL/min	2-20 mL/min	7-70 mL/min	350-2,300 mL/min
System Capacity	0.7-7 L/day (0.2-2 GPD)	1.5-15 L/day (0.4-4 GPD)	3-30 L/day (0.5-5 GPD)	10-100 L/day (2.6-26 GPD)	194-1,940 L/day (51-510 GPD)
Min. Batch Volume (per Cell)	300 mL	3.7 L (1 gal)	3.7 L (1 gal)	3.7 L (1 gal)	15 L (4 gal)
Max. Pump Capacity	N/A	6.8 LPM (76 bar) 1.8 GPM (1,100 psi)	6.8 LPM (76 bar) 1.8 GPM (1,100 psi)	6.8 LPM (76 bar) 1.8 GPM (1,100 psi)	6.8-38 LPM (76 bar) 1.8-10 GPM (1,100 psi)
Cell Material	SS316, Hastelloy™	PTFE, Delrin, Acrylic, SS316, Hastelloy™	PTFE, Delrin, Acrylic, SS316, Hastelloy™	Acrylic, SS316 Hastelloy™	SS316
Max. Operating Pressure	HP4750: 69 bar (1,000 psi) HP4750X: 172 bar (2,500 psi)	PTFE/Acrylic: 27.6 bar (400 psi) Delrin/SS316/Hastelloy™: 69 bar (1,000 psi)	PTFE/Acrylic: 27.6 bar (400 psi) Delrin/SS316/Hastelloy™: 69 bar (1,000 psi)	Acrylic: 27.6 bar (400 psi) SS316/Hastelloy™: 69 bar (1,000 psi)	41.4 bar (600 psi)
Filtration Mode(s)	Dead-End Stirred Cell	Cross Flow, Forward Osmosis	Cross Flow, Forward Osmosis	Cross Flow, Forward Osmosis	Cross Flow

NOTES:

Founded in 2001 in Kent, WA, Sterlitech Corporation manufactures and markets filtration-focused laboratory products to a broad spectrum of scientific and industrial sectors. Its line of flat sheet membranes and tangential flow cells deliver industry-leading performance and reliable results. Configured for reverse osmosis, nanofiltration, ultrafiltration, and microfiltration applications, Sterlitech's bench scale test equipment provides the versatility required to innovate.

Sterlitech's comprehensive line of products is supported by the expertise of its technical specialists who can assist with application-specific product selection, and provide customized solutions where necessary. Unique problem-solving approaches, flexibility, and consistent quality have made Sterlitech Corporation a renowned global provider of filtration products and equipment.

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