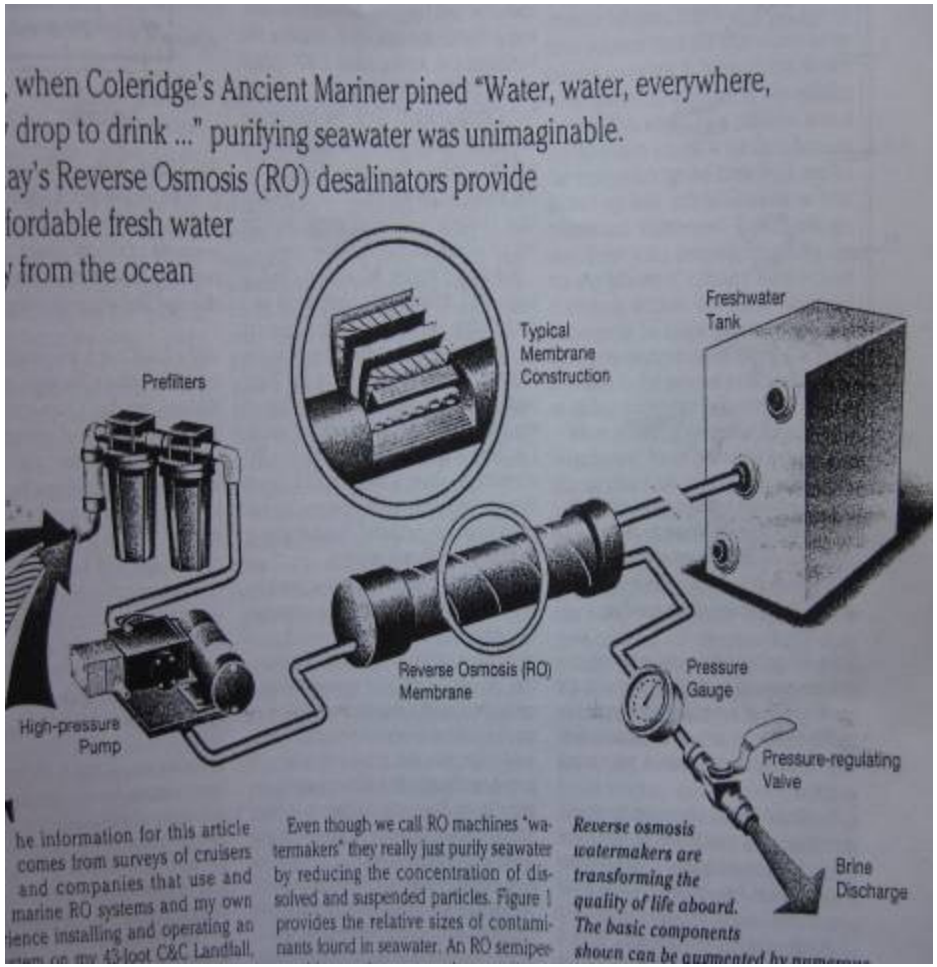
Making Your Own Watermaker

- Dave & Sherry McCampbell
- Workable alternative to high cost of kits & commercial units
- svsoggypaws.com
  - This presentation
  - More engineering details & pics in Plumbing

Presentation Given as SSCA Webinar Dec 2011

Why Make Your Own

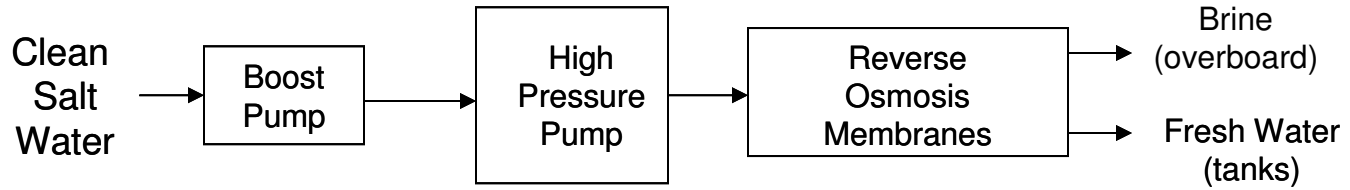
- Cost 40 gph modular:
  - Spectra $16K
  - SK $12K
  - Aqua Marine kit $6K
  - Cruise RO kit $5.3K
  - DIY $2-4K
- Engineering efficiency
- Familiarity with system & repair
- Cost of proprietary spares
- Fun project



Outline

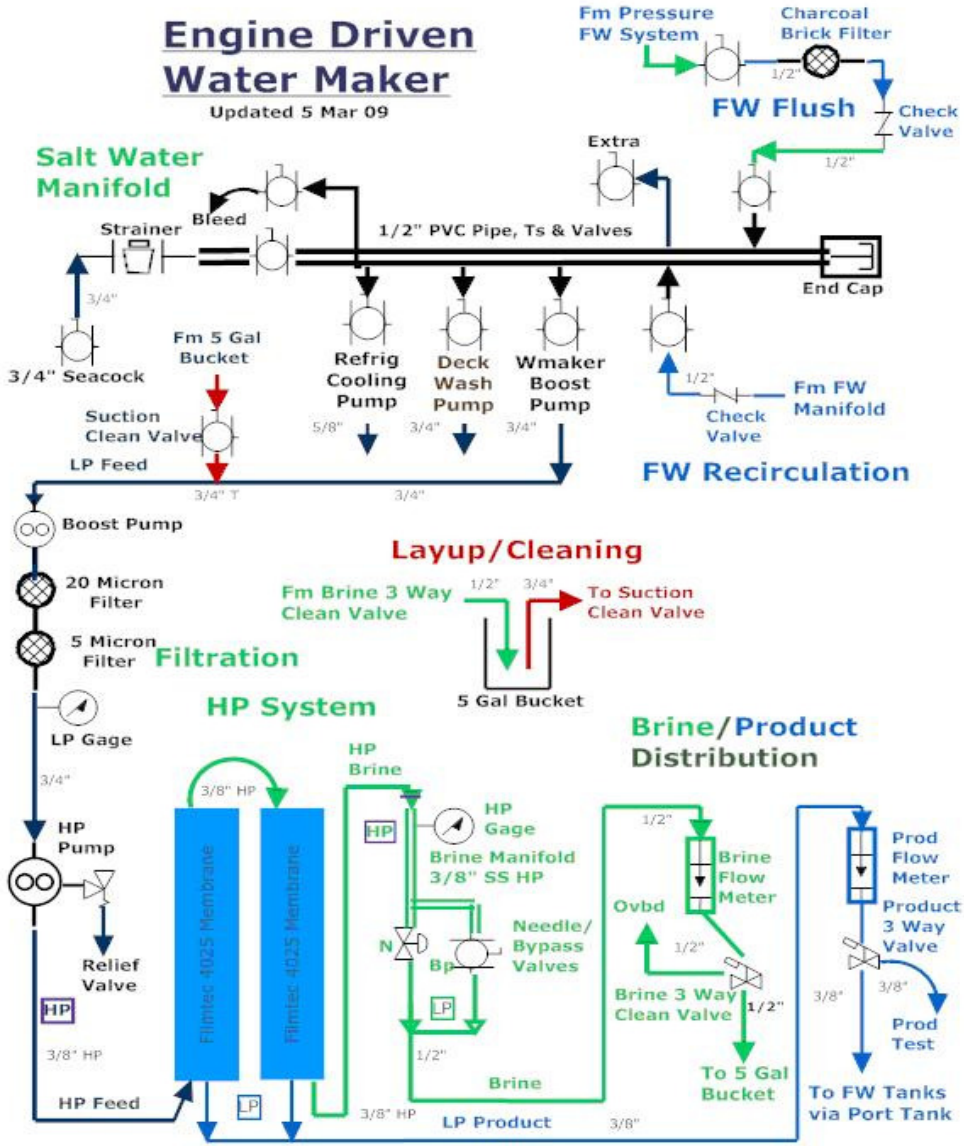
- Layout
- Engineering
- Components
- Parts List
- Operation
- Maintenance

Simplified Watermaking Diagram



Not shown: Filters, gauges, recirculation paths

Layout Feed



- Feed-
  - External screen
  - Seacock
  - Strainer
  - SW Manifold
  - Boost pump
  - Filters
  - LP gauge
  - HP pump
  - Relief valve
  - Snubber
- Fresh Water Flush
  - Filter/valves

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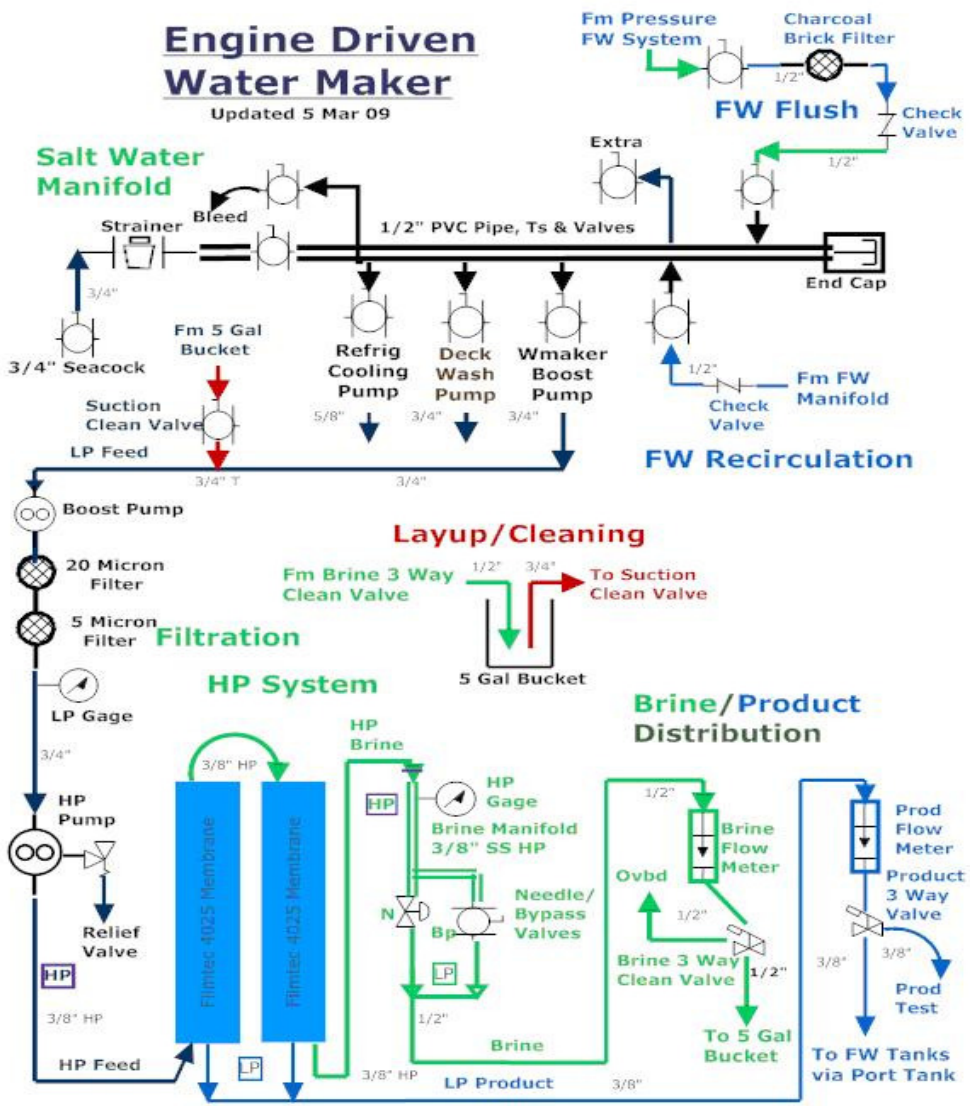
Layout Brine and Product



- Brine-
  - Membrane tubes
  - Membranes
  - HP gauge
  - HP control valve
  - HP bypass valve
  - Flow meter
  - 3 way valve
  - Overboard/Clean
- Product
  - Flow meter
  - 3 way valve
  - Tank/Test
- Layup/Cleaning
  - 5 gal bucket

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Engineering

- KISS – No electronics!!
- Terms:
  - Feed (gpm) = Brine (gpm) + Product (gph)
- Safe Membrane Flow:
  - Each 2.5” x 40” membrane = 21 gph max product
  - Two membranes = ~40 gph max product
  - Need 3-4 gpm flow across membranes for scouring
- Hose sizes-
  - Feed - LP ¾”, HP 3/8”
  - Brine – 3/8” HP, ½” LP
  - Product - 3/8” LP
  - Maintain hose ID/flow thru fittings

High Pressure Side Engineering

- System Pressures:
  - Max 1000 psi – relief valve
  - Operating max 850 psi – control valve
- Pump for 40 gpm system:
  - Type – Triplex high pressure pump by Cat, Hypro, Giant, others
  - Head material – bronze, stainless steel or titanium
  - Rated flow rate - 4-5 gpm
- End fittings:
  - Best - reusable screw on, also crimp
  - Stainless steel or bronze

Low Pressure Side Engineering

- Low Pressure Feed System:
  - Maintain positive head pressure on HP pump
  - Operating feed pressure ~2-20 psi
  - Feed flow min .5 gpm more than HP
- Boost Pump:
  - DC preferred, AC option
  - Jabsco Water Puppy or similar
  - Mount below waterline
  - Use deep dedicated seacock
- Fittings:
  - Quality plastic w/ hose clamps

Engineering Basics

- Makes more product in warm salt water, less in cold water
- World health standard is 500 ppm salts, >> clean membranes when 450 ppm
- Need to be able to sample both product and brine water discharges
- Bigger HP pumps need about 2 HP
- Drive options are main engine or 120 v generator, not 12 v

Major Components

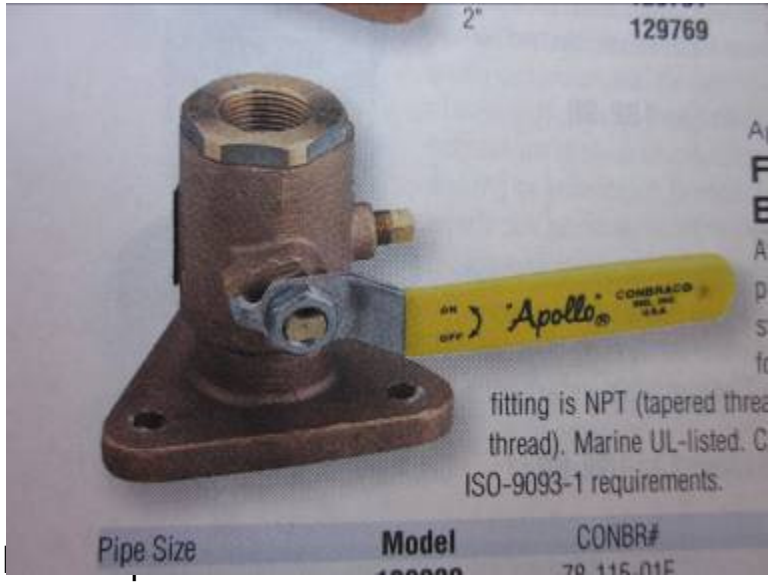
- External screen
- Seacock
- Strainer
- Salt water LP manifold
- Boost pump
- Filters
- LP gauge
- HP pump
- Relief valve
- Snubber
- Membrane pressure vessels
- Membranes
- HP manifold
- Pressure control valve
- Bypass valve
- HP gauge
- Brine flow meter
- Brine 3 way valve
- Product flow meter
- Product 3 way valve
- LP hose, fittings
- HP hose, fittings

External Screen

- Better than internal basket strainer
- Removable heavy screen for inspection, cleaning
- Screens out all grass, jellyfish, etc
- Size to cover 1 or 2 thru hulls
- All bronze
- ~$100-200, Lewis Marine

Seacock

- Allows positive raw water shut off
- 3/4” ID minimum
- Bronze or Marelon
- ¼ turn ball valve
- Deep mounted
- ~$60, marine stores

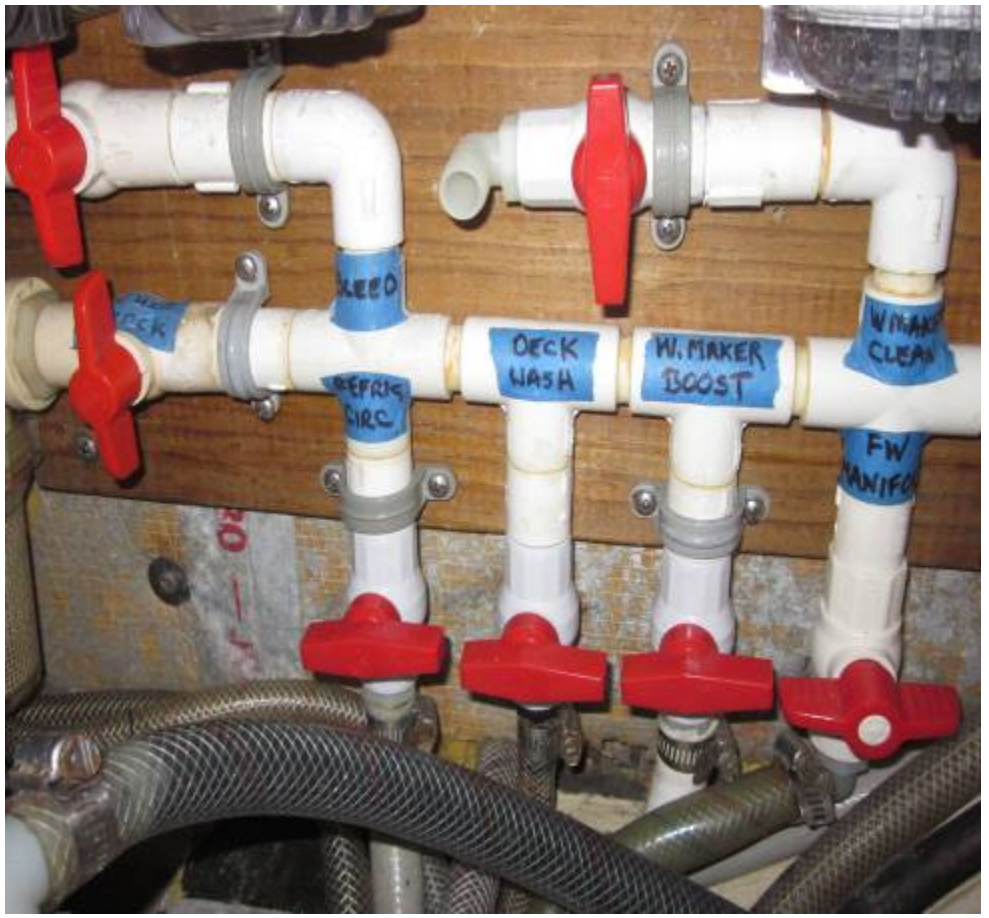


Strainer

- Protects system from large contaminants
- Clear plastic
- 3/4" plastic fittings
- Easily accessible
- SS screen
- ~$35, marine stores

Salt Water Low Pressure Manifold

- Allows multiple taps from one seacock
- 1/2" PVC Schedule 40 pipe, fittings and valves
- In - salt water, fresh water flush
- Out – water maker feed, refrig, deck wash, etc
- Shut off valve, bleed valve
- ~$25, hardware stores



Boost Pump

- Provides positive head on high pressure pump
- Flexible impeller (self priming), centrifugal
- Does not need to be continuous use
- Jabsco Water Puppy #18660, 18610 or equivalent
- 12/120 volt, ~6 GPM
- ½" FNPT fittings
- ~$50 used, $120 new (Amazon) or Depco Pump

Fresh Water Flush Filter

- For fresh water flushing system after every use, removes chlorine
- Housing- standard household, OPAQUE not clear, ¾” fittings
- Element- heavy charcoal brick, not basic charcoal
- Valve on each side and safety check valve before manifold
- Housing ~$30
  Charcoal element ~$5-15
  Ebay

Filters

- For duplex system filtration to 5 microns
- Housings – 2 ea, standard household, clear, 3/4" fittings
- Elements – 1 ea 20 & 5 micron
- Can clean 2 times before replacing
- Housings ~$25 Elements - $2-12
- Source polypropylene-- NOT paper or string wound elements on internet/eBay

LP gauge

- Measures LP feed pressure and allows monitoring of filter condition
- All SS case/fittings
- Oil filled
- -30 to +70 PSI
- ¼” bottom fitting
- ~$60, McMaster Carr

HP Pump

- Raises system pressure to HP
- Need SS mount, clutch?
- HP pump for 40 gph system
  - Type – HP triplex plunger
  - Mfg - Hypro, Cat, Giant, etc
  - Head – bronze, SS or titanium
  - Bronze head ~1000 hr life = 50hrs/yr X 20 years@40gph
  - Flow rate - 4-5 GPM
  - Cost
    - Bronze ~$350-800
    - SS/Titanium ~$1500
  - Source on internet

Relief/Pop Off Valve

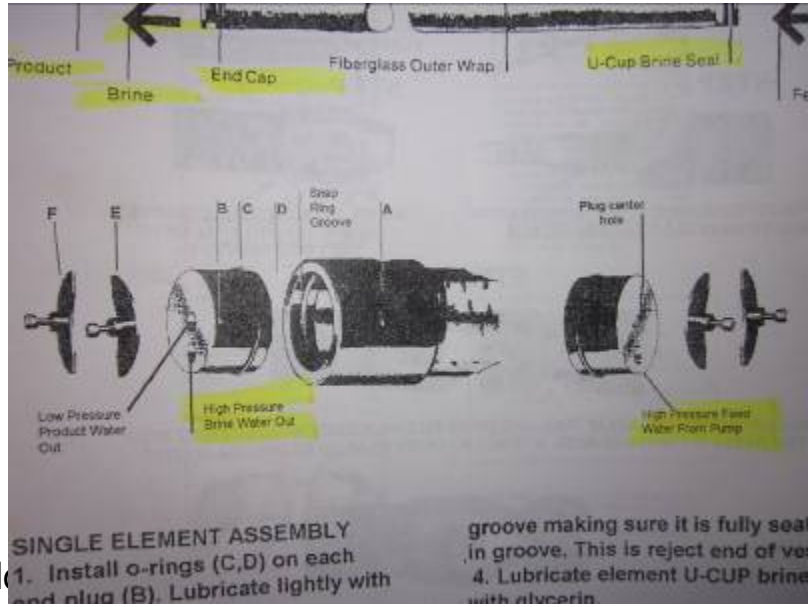
- Relieves pressure in case of system blockage at ~1000 psi
- Cat Pumps nr 33960 or equal
- Adjust to 1000 PSI
- 3/8” MNPT fitting
- ~$30-70, Cat Pump dealer

Pulsation Dampener

- Dampens pulsations from HP pump
- How it works: Air in the snubber smoothes downstream vibration /chafe in HP hose
- Hypro 3375-0017-2 ($100)
- or 36” X 3/8” ID HP hose blocked off at one end
- 3/8” MNPT fitting to pump
- ~$20-80, Hypro or hose dealer

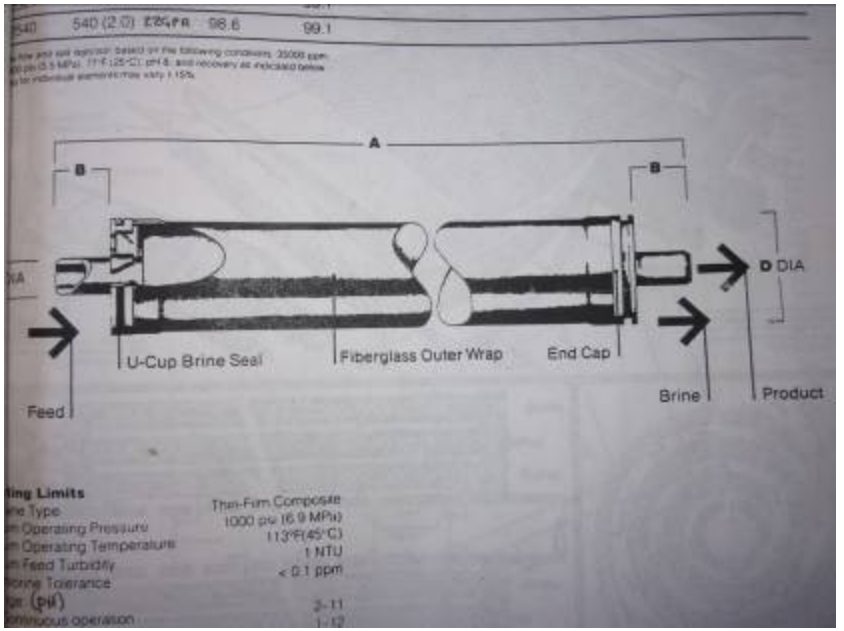
Membrane Pressure Vessels

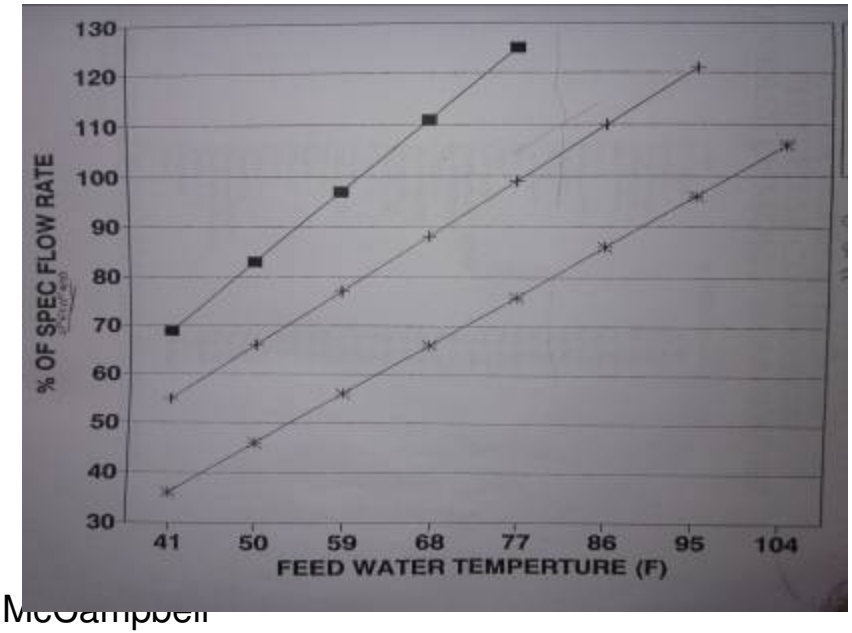
- Hold 2.5” X 40” membranes
- 2 ea, fiberglass tubes with stainless end caps or equal
- Mount securely to bulkhead
- ~$25 used (shop carefully!) ~$250 new Aqua Marine
- CruiseROWater.com sells as a kit with matching membranes



Membranes

- Separate product from brine under HP pressure
- 2 ea, FilmTec SW30-2540
- $200-$500 new, eBay (shop carefully), CruiseRO
- Note flow variance with temperature
- ~1 year shelf life, 5-10+ year life installed





HP Manifold

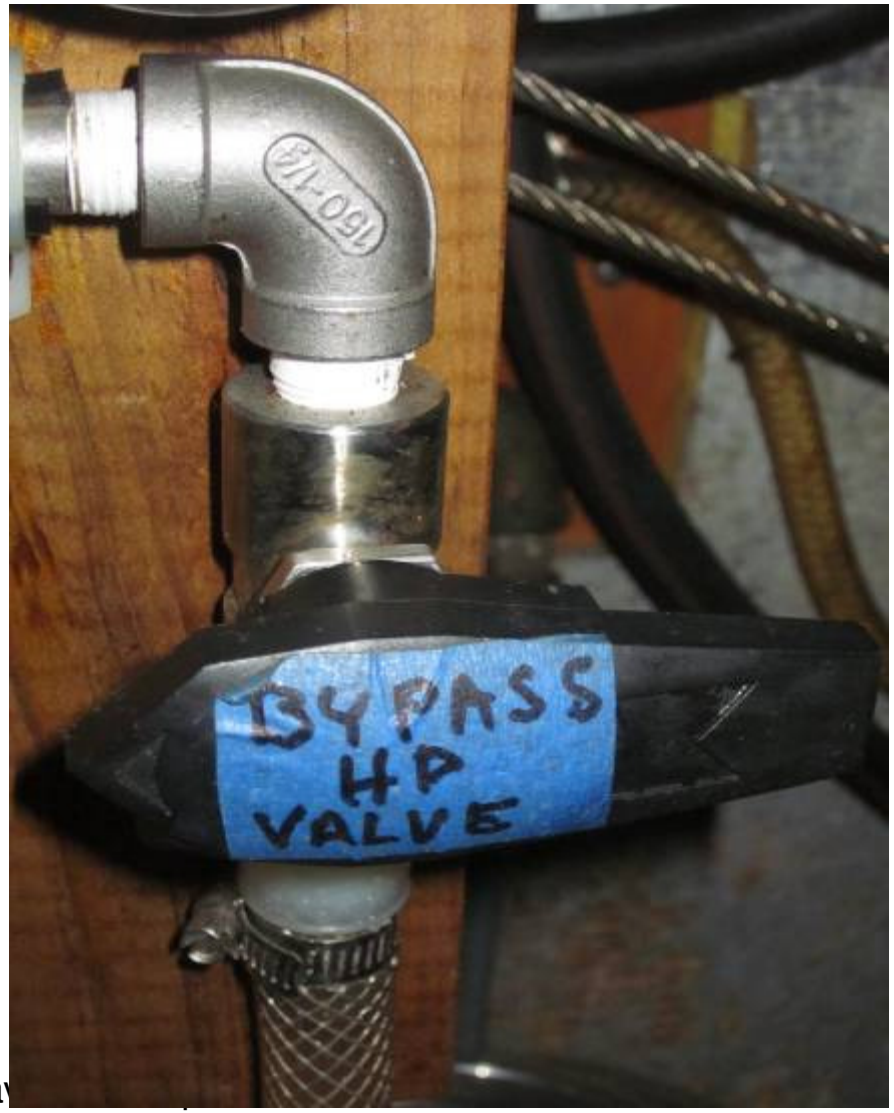
- Mounting for HP control valves and gauge
- All 1/4” SS fittings
- SS 316 vs 304
- Issue – HP 150 psi test fittings?
- Available fm McMaster Carr & elsewhere
- $5-$10 each fitting

Pressure Control Valve

- Allows for precise brine pressure & volume regulation
- Dragon, 316 SS, 6000 PSI or equal
- 1/4” FNPT fittings
- ~$40-75, Dragon/Ebay

Bypass Valve

- Allows quick bypass of pressure control valve in case of blockage
- Use during flushing and cleaning
- All SS, quarter turn, 1000 PSI minimum SWP
- 1/4” FNPT fittings
- ~$30-40, McMaster Carr



HP gauge

- Indicates HP brine pressure and filter condition
- All SS case/fittings
- Oil filled
- 0-~1400 PSI
- ¼” NPT bottom fitting
- ~$70, McMaster Carr

Brine Flow Meter

- Indicates brine flow in gpm
- Dwyer VFB-86-SS or equal
- All SS fittings
- 0-5.0 gpm scale
- ¼” fittings on back
- ~$70, Dwyer

Brine 3 Way Valve

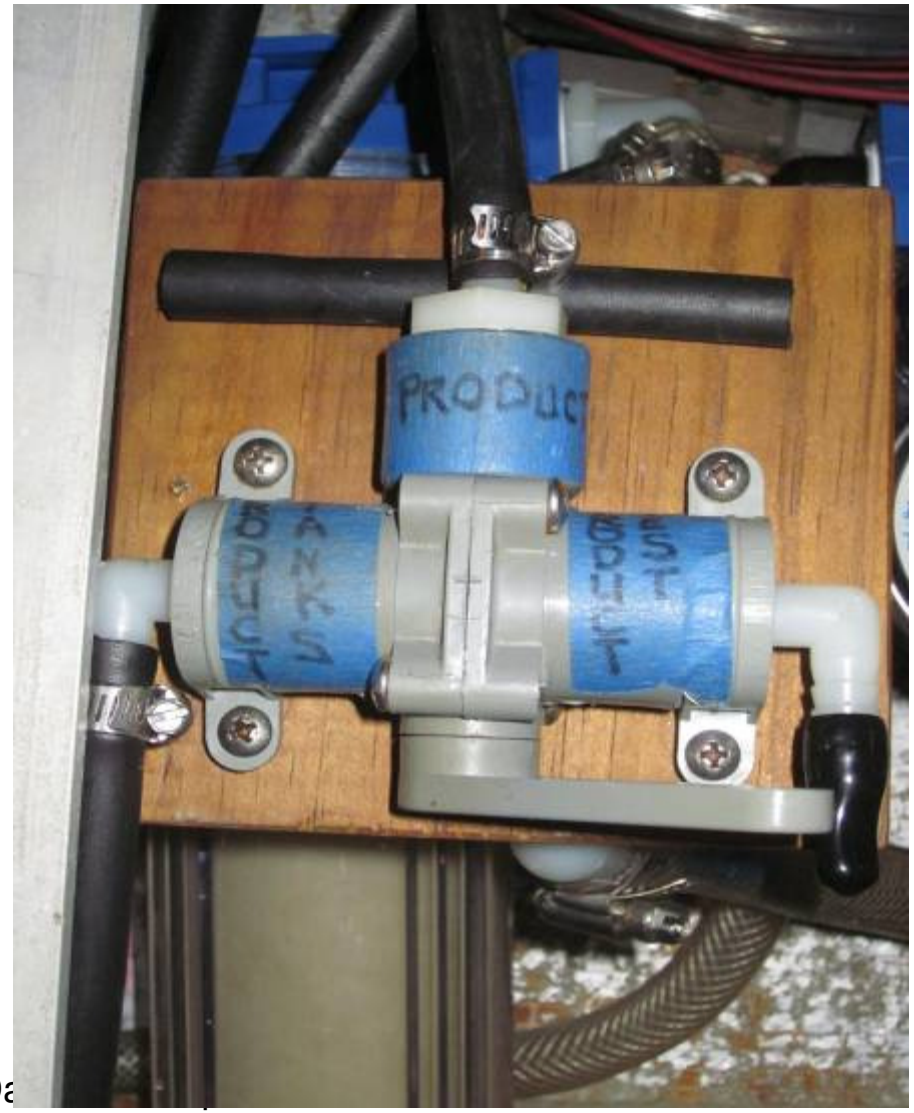
- Allows switching brine discharge between overboard and recirc.
- Grey plastic
- 1/2" FNPT fittings
- Available from most watermaker stores
- ~$40 new ~$10 used Wmaker stores, eBay

Product Flow Meter

- Indicates product flow and membrane condition
- Dwyer VFB-81-SS or equal
- All SS fittings
- 6-60 gph scale
- 1/8” fittings on back
- ~$70, Dwyer

Product 3 Way Valve

- Allows switching product discharge between test and tank
- Grey plastic
- 1/2" FNPT fittings
- Available from most watermaker stores
- ~$40 new ~$10 used Wmaker stores, eBay

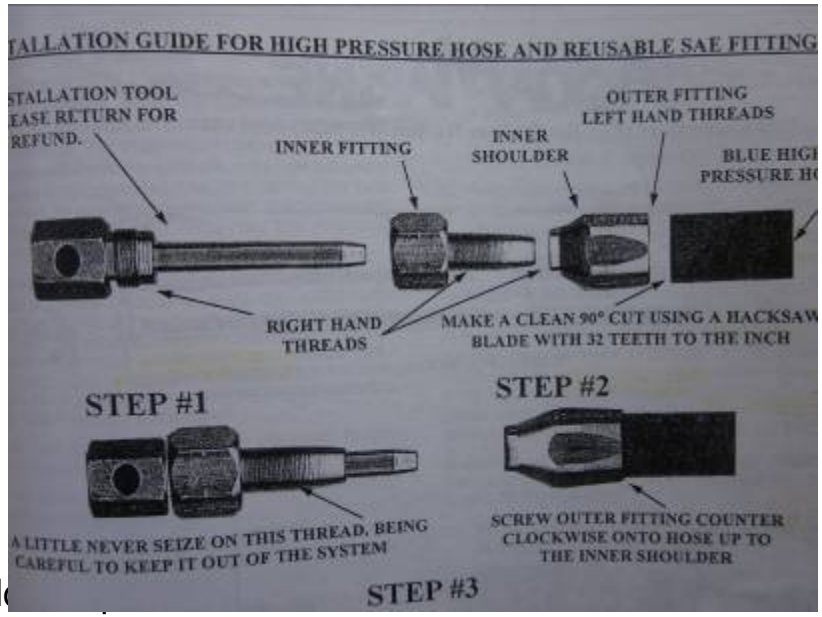


LP Hose, Fittings

- Used in LP feed, brine and product sections of system
- Feed & brine - 3/4" & 1/2" clear reinforced hose
- Product - 3/8” opaque plastic hose
- Plastic fittings to suit
- Maintain hose ID thru fittings
- Available at most hardware stores

HP Hose, Fittings

- Used between HP pump, membranes and HP manifold
- 3/8" ID, 2000 psi or better
- Reinforced drinking water hose w/ PFTE inner liner
- 316 SS or bronze replaceable fittings to match, crimp on?
- Carry spare hose & fittings
- Hose ~$8/ft, Parker, others? Fittings ~$100 ea VMarine, $20-50 ea, McMaster Carr?



Major Parts List 1

- HP Plunger Pump
  - Hypro 2345B-P, 4.8 GPM, 1/2” & 3/8” NPT fitts
  - Mount for HP Pump - Custom SS to fit engine
  - Size pulley to run pump at about 1700 RPM
  - Adjustable Pop Off Relief Valve – Cat Pumps nr 33960, 1000 PSI, 3/8” NPT fitt
  - Snubber – 36” 3/8” HP hose, 3/8” MNPT fitting
- Boost Pump - Jabsco Water Puppy 18660, 12 Volt, 6 GPM, ½” FNPT fittings
- Pressure Vessels - 2 ea, Codeline 25M100, 40”
- Membranes - 2 ea, Filmtec SW30-2540
- Filter Housings - 3 ea, 2 clear & 1 opaque, 3/4" fitts

Major Parts List 2

- Water Filter Elements – non paper, 1 ea 20 micron, 5 micron, charcoal brick, spares
- Flow Meters - Dwyer, clear plastic & all 316 SS fittings;
  - Brine VFB-86-SS, 0-5 gpm, ¼" fittings
  - Product VFB-81-SS 6-60 gph, 1/8" fittings
- Pressure Gauges - all 316 SS case & fitts, oil filled,
  - HP 0-~1400 PSI
  - LP ~-30 to ~+70 PSI, ¼" fittings
- HP Manifold -1/4" NPT 316 SS fittings
- Regulating Valve - Dragon, 316 SS, 6000 PSI, 1/4" NPT fitts
- Bypass Valve - quarter turn, 316 SS, 1000 PSI, 1/4" NPT fitts
- 3 Way Valves – 2 ea, grey plastic, 1/2" NPT fitts

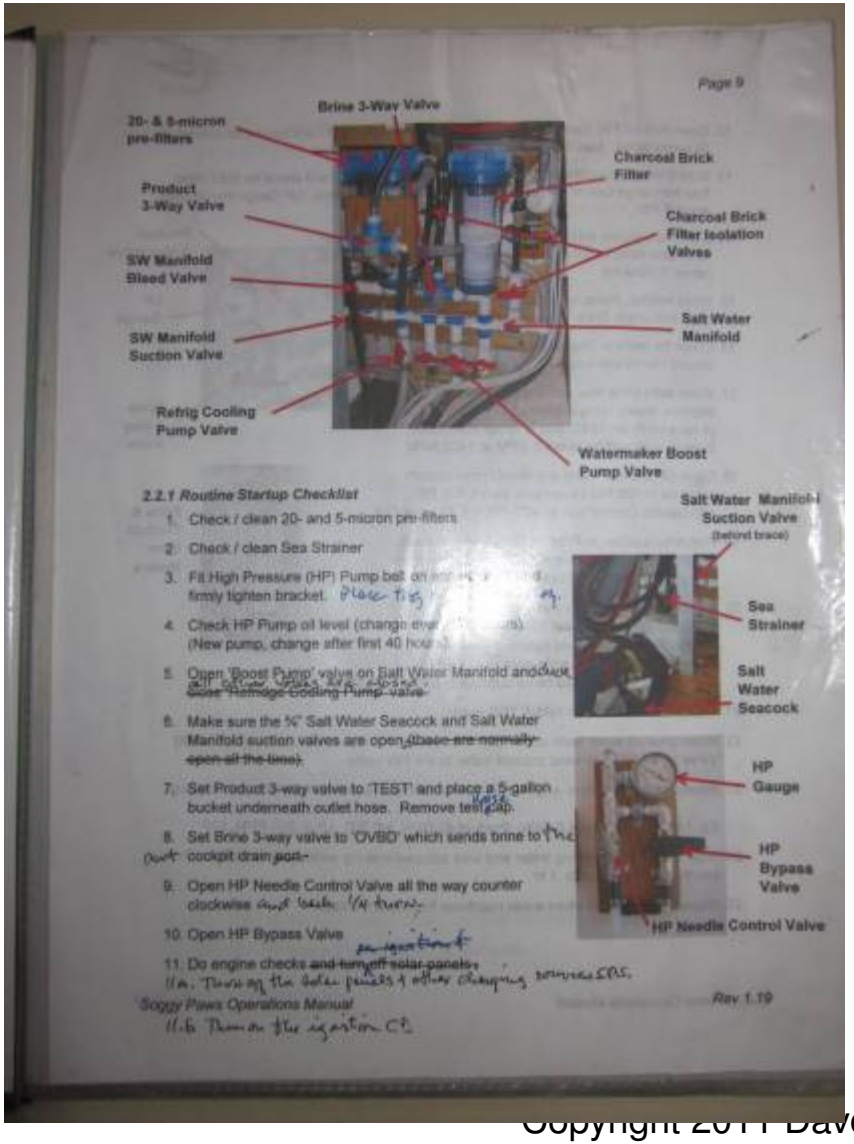
Major Parts List 3

- Hose and Fittings-
  - HP - 3/8" ID hose, 316 SS/bronze replaceable fittings to suit
  - LP - 3/8", 1/2" and 3/4" ID hose, plastic fittings to suit
- Strainer – clear plastic, SS screen, 3/4" fittings
- Seacock – 3/4” bronze ¼ turn ball valve
- Salt Water Manifold - 1/2" sked 40 PVC pipe, fittings and valves
- Mounts - misc sizes of 3/4" varnished wood to suit, grey plastic pipe hangars
- Salinity Test Meter - Hanna TDS 1 (hand-held)
- Electronic Tachometer - Neiko Digital Tach

Good Parts Sources

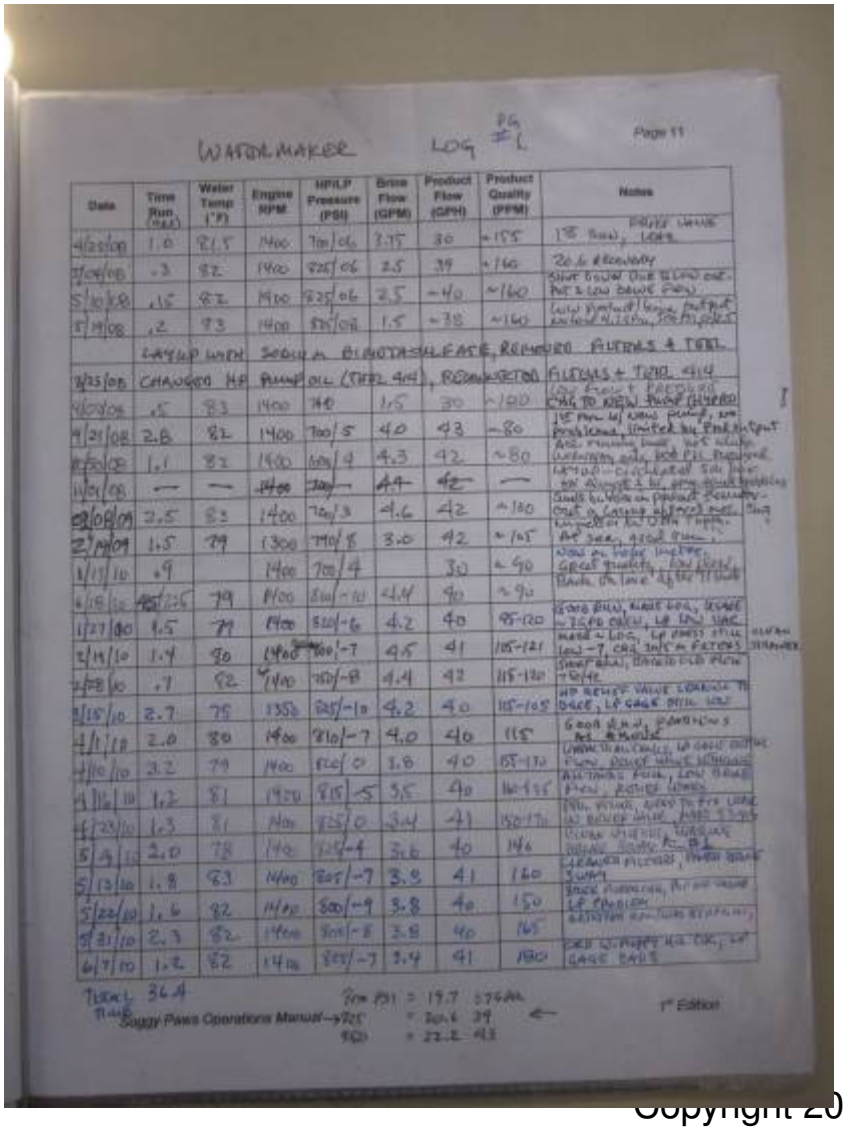
- DepcoPump.com – huge pump and parts inventory
- McMaster.com – Web based, huge parts inventory
- HyproPump.net – least expensive triplex bronze pumps
- CruiseROWaterandPower.com – kit water makers, parts
- AquaMarineInc.net – kit water makers, parts
- SeaTechMarineProducts.com – water makers
- VillageMarine.com – water makers, parts
- SKWatermakers.com – water makers, parts
- CatPumps.com – water maker pumps
- EchoTecWatermakers.com – water makers
- Home Depot, Ace, etc – plumbing parts, mounts
- More Links: svsoggypaws.com/workshop_links.htm

Operation



- Startup
- Making water
- Shut down
- Fresh Water flushing

System Operating Record



WATERMAKER LOG

Date	Time Run (Hrs)	Water Temp (°F)	Engine RPM	HP/LP Pressure (PSI)	Brine Flow (GPM)	Product Flow (GPH)	Product Quality (PPM)	Notes
4/25/08	1.0	81.5	1400	700/06	3.75	30	~155	
5/04/08	.3	82	1400	825/06	2.5	39	~160	
5/10/08	.15	82	1400	825/06	2.5	~40	~160	
5/11/08	.2	83	1400	850/08	1.5	~38	~160	
	LAYUP WITH SODIUM BISULFATE, REMOVED FILTERS & TEST.							
9/23/08	CHANGED HP PUMP OIL (TEST 4:14), RECOMMISSION FILTERS & TEST 4:14							
10/04/08	.5	83	1400	740	1.5	30	~100	
9/21/08	2.6	82	1400	700/5	4.0	43	~80	
9/30/08	1.1	82	1400	600/9	4.3	42	~80	
10/01/08	—	—	1400	740	4.4	42	—	
02/08/09	2.5	83	1400	720/3	4.6	42	~130	
2/19/09	1.5	79	1300	770/8	3.0	42	~105	
1/17/10	.9		1400	700/4		30	~90	
1/15/10	1.5	79	1400	820/-10	4.4	40	~90	
1/27/10	1.5	79	1400	820/-6	4.2	40	95-120	
2/14/10	1.4	80	1400	800/-7	4.5	41	115-121	
2/28/10	.7	82	1400	760/-8	4.4	42	115-120	
3/15/10	2.7	75	1350	825/-10	4.2	40	115-105	
4/1/10	2.0	80	1400	810/-7	4.0	40	115	
4/10/10	2.2	79	1400	810/0	3.8	40	85-110	
4/16/10	1.2	81	1400	815/-5	3.5	40	110-125	
4/23/10	1.3	81	1400	825/0	3.4	41	150-170	
5/9/10	2.0	78	1400	825/-4	3.6	40	146	
5/13/10	1.8	83	1400	805/-7	3.9	41	160	
5/22/10	1.6	82	1400	800/-9	3.8	40	150	
5/31/10	2.3	82	1400	805/-8	3.8	40	165	
6/7/10	1.2	82	1400	805/-7	3.4	41	180	

- Columns for:
  - Date
  - Run time Hrs
  - Engine RPM
  - HP pressure PSI
  - LP pressure PSI
  - Brine flow GPH
  - Product flow GPM
  - Product quality PPM
  - Notes

Start Up Basics

- Ensure clear salt water with no petroleum or soaps
- Open all salt water & control/bypass valves
- Route brine overboard, product to test into bucket
- Start boost pump FIRST, then HP pump
- Close bypass then slowly bring pressure up in 100 psi increments with control valve
- Let bubbles settle out in brine sight glass between increments
- Adjust pressure for 40 gph product flow
- Take first round of system readings
- When PPM is below 500 switch product to tank

Making Water Basics

- Monitor system flow and pressures
- Take readings at least every half hour
- Maintain constant engine speed
- Adjust control valve as necessary for 40 gph product flow
- Watch for leaks
- Watch tank fills and vents to see when full

Shut Down Basics

- When tanks are full, divert product to test bucket w/ product 3 way valve
- Take final set of system readings
- Reduce system pressure slowly to zero with pressure control valve
- Secure engine and then boost pump
- Perform fresh water flush

Fresh Water Flush Basics

- Secure SW seacock and manifold inlet valves
- Open all HP valves, brine 3 way to overboard, product 3 way to test
- Route FW from boat's pressure FW system through charcoal filter to flush system
- Flush all SW out of system with only boost pump and/or boat's FW pump
- Taste test brine until fresh
- Close off system with HP & SW manifold and brine 3 way valves
- Leave product 3 way valve on test
- Shut off fresh water flush system

Maintenance

- SMB layup
- Cleaning
- Cleaning filters
- Changing membranes
- Leaks
- Contaminants

Layup with Preservative (SMB)

- Flush system with Fresh Water
- Use Sodium Meta Bisulfate,1 oz SMB per 1 gallon of FW, multiple sources
- 5 oz SMB for 3 gallon system plus 2 gals of water in 5 gallon bucket
- Place cleaning hose and brine discharge into 5 gallon bucket
- Circulate preservative for about 10 mins w/ boost pump
- Connect brine and cleaning hoses for closed loop
- Circulate SMB every two weeks for 5-10 minutes if layup for more than two months

Cleaning

- Clean membranes only if absolutely necessary, product greater than ~450 ppm salts
- Algae cleaner removes biological contamination
- Scale cleaner removes mineral contamination
- Follow cleaner instructions
- Use layup closed loop system with bucket

Cleaning Filters

- Remove elements from housings
- Block off one end of element and:
  - flush with F/SW hose from inside out or
  - forcefully dunk in liter container with water or
  - tow behind dinghy/boat for ~10 mins
- Reverse ends and repeat
- Inspect for cleanliness and reinstall
- After second cleaning, discard elements and install new

Changing Membranes

- Ensure system pressure at 0 psi
- Remove upstream end cap of pressure vessel
- Carefully extract old membrane observing orientation of cupped orings, discard
- Read any new membrane instructions carefully
- Inspect soft parts for damage/contamination, very lightly coat with glycerin or silicone grease
- Push membrane carefully into upstream end of pressure vessel observing proper orientation of cup orings
- Reseat pressure vessel end caps and hose fitts

Leaks & Contaminants

- Inspect system for leaks during each run
- Tightly secure HP hose for vibration using chafe protection where necessary
- Use thread seal on all fittings and tighten securely
- Avoid ANY petroleum or chlorine contamination into system
- In general, do not make water in commercial or crowded harbors

More here…

http://svsoggypaws.com

http://svsoggypaws.blogspot.com

ssca.org

Acronyms and Terms Used

AC – Alternating Current (120v)
Brine – The waste Salt Water output by the membranes
DC – Direct Current (12v)
DIY – Do It Yourself
DWL – Designed Water Line
FW – Fresh Water
FNPT – Female National Pipe Thread
Gpm – Gallons per minute
Gph – Gallons per hour
HP – High Pressure
LP – Low Pressure
NPT – National Pipe Thread
PPM – Parts Per Million (measure of how much salt is in the product water)
Product – The Fresh Water output by the membranes
PSI – Pounds per square inch (a measure of pressure)
SMB – Sodium Metabisulfate (storage preservative for membranes)
SS – Stainless Steel
SW – Salt Water