



USER'S GUIDE TO:

Phoenix Vessel Technology Limited 8" x 175 psi / 300 psi / 450 psi / 600 psi END PORT PRESSURE VESSELS

Phoenix Vessel Technology Ltd
Unit 2, The Old Bakery, Lower Tuffley Lane
Gloucester, GL2 5DP, U.K.
Tel +44 (0)1452 311673
Fax +44 (0)1452 310295



TABLE OF CONTENTS

	Page No:
FORWARD	3
SECTION 1 'Maintenance Guide'	4
1.1 Removing End Cap from Vessel	4
1.2 Disassembling End Cap	7
1.3 Rebuilding End Cap	9
1.4 Loading Membranes	11
1.5 Closing Vessel	14
SECTION 2 'Installation'	16
2.1 Handling	16
2.2 Vessel Support Position	17
2.3 Mounting and Connecting to Vessels	18
SECTION 3 'Operation'	19
3.1 Corrosion	19
3.2 Operating Conditions	20
3.3 Safety Precautions	21
3.4 Chemical Compatibility	22
SECTION 4 'Appendix'	24
4.1 Spare Parts List	24

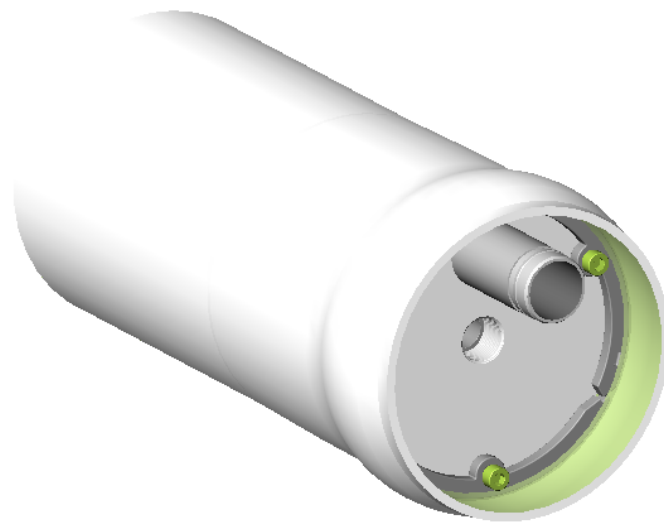


FORWARD

Phoenix Vessel Technology is a major manufacturer of Glass Reinforced Plastic Pressure vessels which are used as housings for reverse osmosis membrane elements. It is one of a small number of companies with Code X accreditation of the American Society of Mechanical Engineers.

Vessels are produced to cover a range of pressures upto 1200 psi and to house seven 40" or five 60" membrane elements.

Each vessel has a documented history in terms of the manufacturing process and the materials used. Before despatch, each vessel is tested upto 1.1 times design pressure to ensure structural integrity.



This User's Guide applies to a range of 8" end ported pressure vessels which have a 1.5" Victaulic feed concentrate port and 1"BSPP female product tube connection. The design of the end cap enables full pressure to be applied to the product connections (provided pipework external of the vessel has the required rating).

The following Assembly Drawings are applicable:

1MNC 3019	- 8" 175 psi	113°F (45°C)
1MNC 3017	- 8" 300 psi	113°F (45°C)
1MNC 3032	- 8" 450 psi	113°F (45°C)
1MNC 3610	- 8" 600 psi	113°F (45°C)

User's Guide History:	Issue1	Apr 2003	(First Release)
	Issue 2	July 2003	(Feed Port Seal Removal Added)
	Issue 3	Apr 2005	(450 psi model added)
	Issue 4	Apr 2008	(600 psi model added)

SECTION ONE

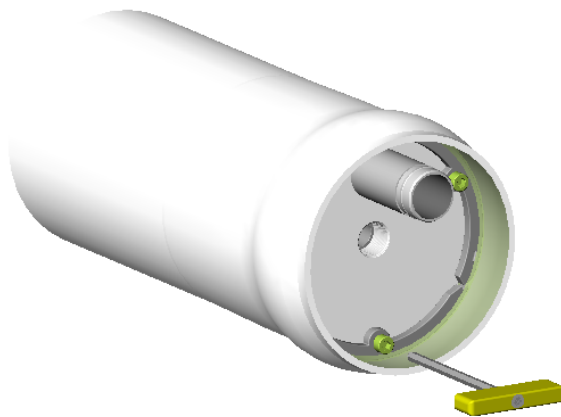
MAINTENANCE GUIDE

1.1 REMOVING END CAP FROM VESSEL

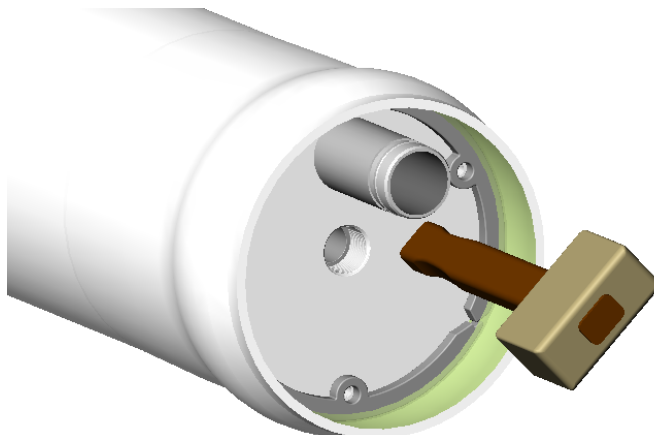
1.1.1 Ensure system is NOT pressurised before starting work.

1.1.2 Remove couplings connecting vessel ports to manifolds and move them clear of the vessel. Remove product connections to the End Cap.

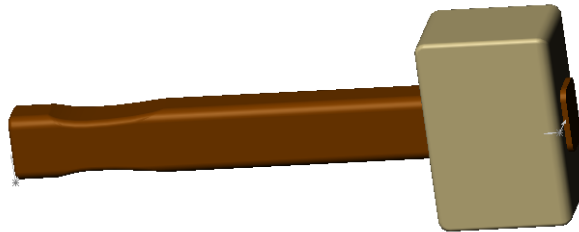
1.1.3 Using an 8mm (A/Flats) hexagonal T bar or Allen key remove the 3 Cap Head Screws located in recesses in the cast Retaining Rings. (Note: 8mm = 5/16").



1.1.4 Remove the 3 segments of the Retaining Ring. Each segment has a slot at one end to enable it to be levered out. If removal is difficult then start at the point where the gap between two segments is greatest. It may be of assistance to tap the End Cap with a wooden hammer shaft to free the segments.



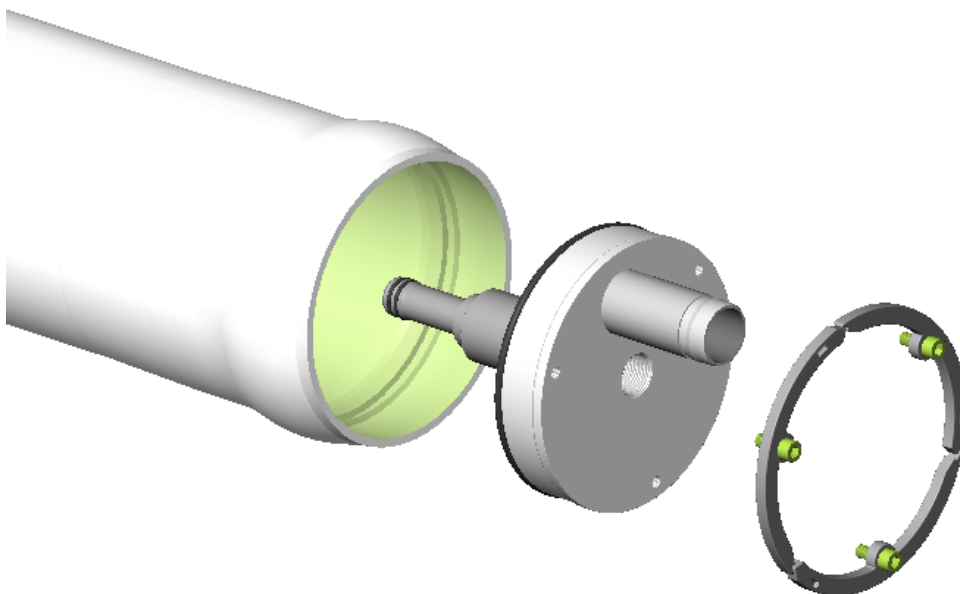
1.1.5 A hammer is a useful tool for removing and inserting the end fittings – however it should be used with discretion and have the following specification.



- (a) Hammer weight 1.0 to 1.5 lbs ('light' to 'medium' weighted).
- (b) Handle length 8-10 inches.
- (c) Handle material from wood, thermoplastic.
- (d) Hammer head from rubber, wood, thermoplastic, metal.
- (e) Hammer head style 'engineers' or as shown above.

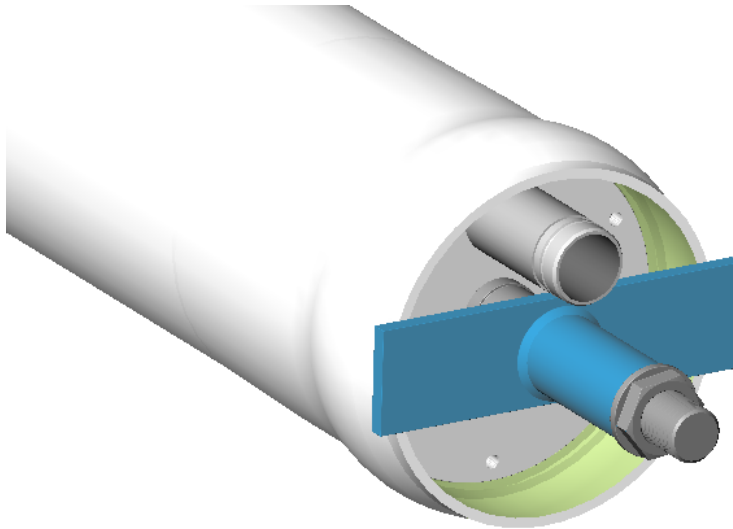
If a metal headed hammer is used the head must not be struck against any part of the pressure vessel or end fittings. The wooden handle is the only part that should be used to assist in breaking the seal between vessel and end cap.

1.1.6 Grasp the 1.5" Feed Concentrate Port and remove the end cap with a gentle rocking motion.

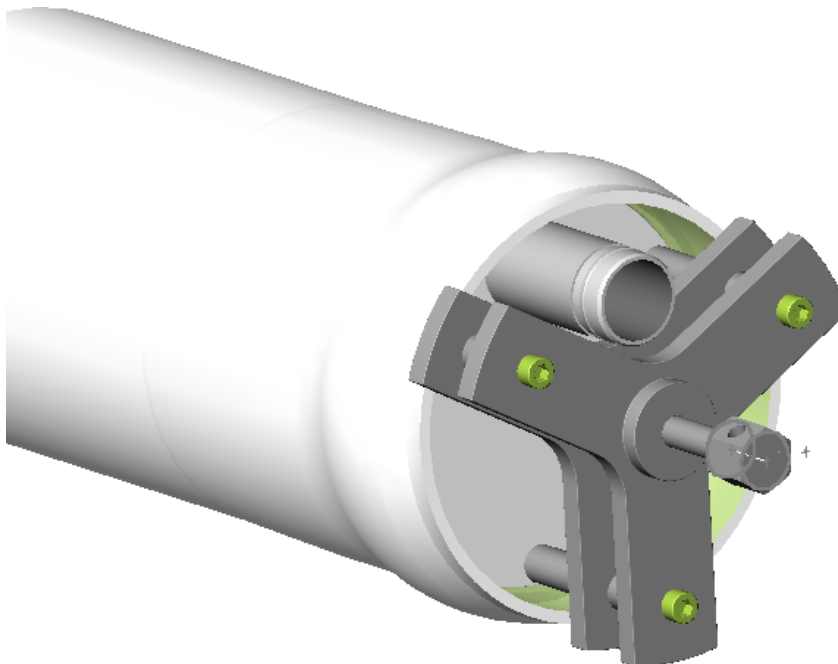


1.1.7 If the End Cap cannot be removed as indicated then the use of an extractor will be necessary. Currently two designs of extractor are available; Phoenix Vessel Technology can supply both.

The first design applies extraction load to the central product port via a threaded adaptor and backnut.

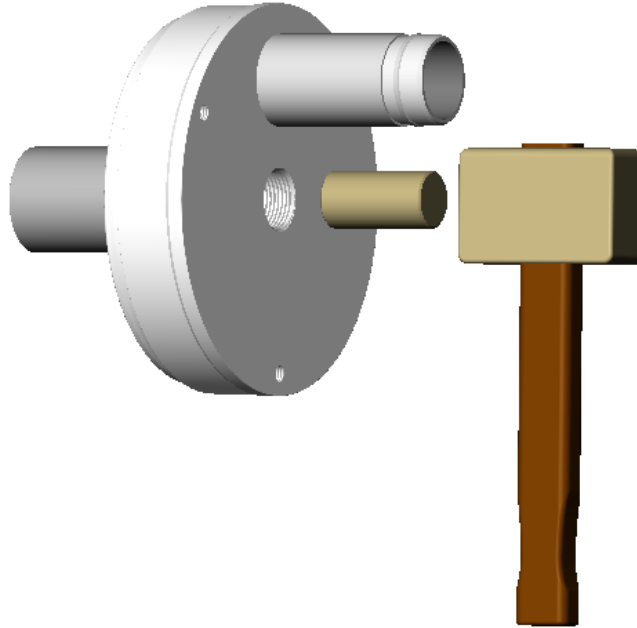


The second design consists of two tripods and 3 long cap head screws (M10x1.5) – these are screwed into the securing screw threads of the End Cap. Extraction load is applied via the large threaded bolt at the centre axis. This is illustrated below.

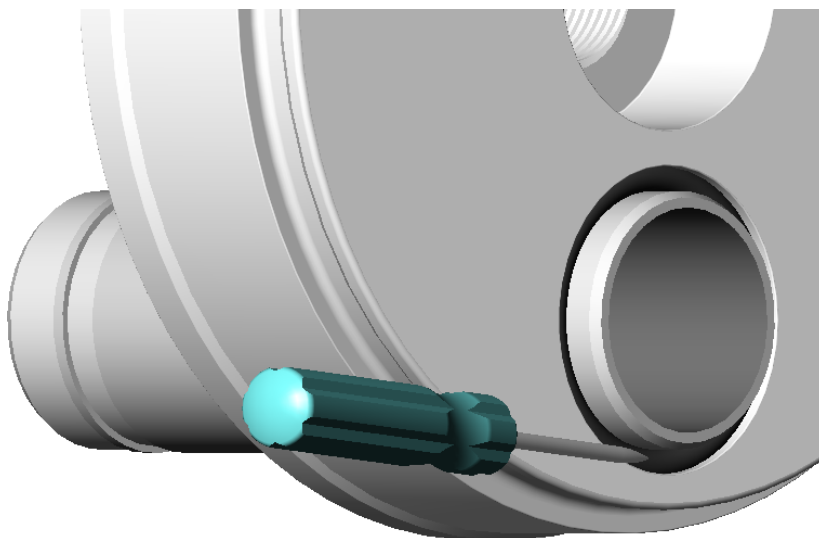


1.2 DISASSEMBLING END CAP

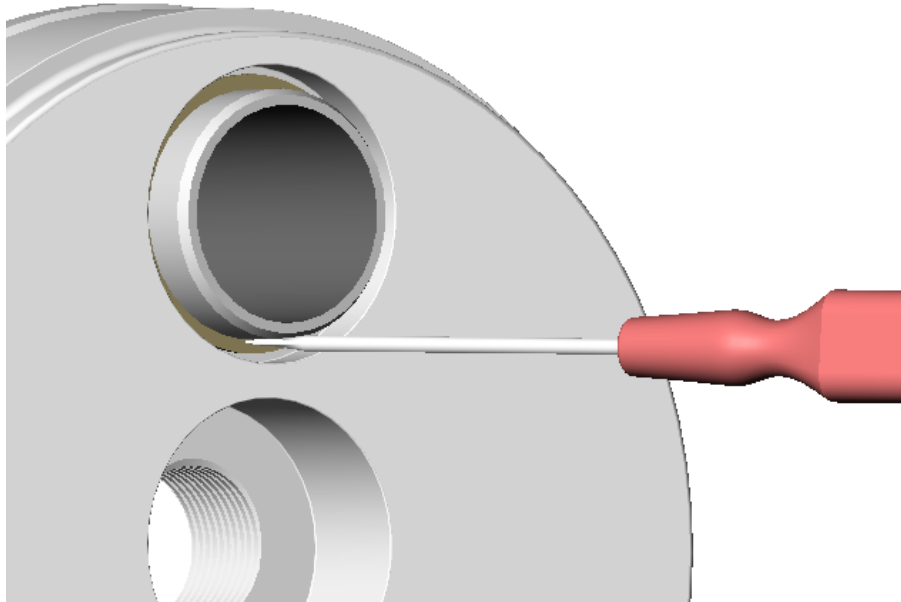
- 1.2.1 To remove the central Hub use a 30mm bar. This will require considerable force (e.g. mallet applied to the bar). Separation of the Hub from the End Cap will result in damage to the pair of O-Seals used for sealing and location. Make sure new O-Seals are fitted.



- 1.2.2 To remove the Feed Concentrate Port first remove the seal using a sharp pointed tool - pierce the O-Seal and lift it out before discarding (make sure spares are available before attempting disassembly). Use a sharp pointed tool designed for making holes in wood or leather. Make sure that the tool does not mark the relatively soft End Cap.



- 1.2.3 Remove the Spiroloc Circlip using a screwdriver. Be careful not to scratch the End Cap material with the screwdriver, as this would require the End Cap to be replaced.



1.3 REBUILDING END CAP

1.3.1 Thoroughly clean all parts and check for the following.

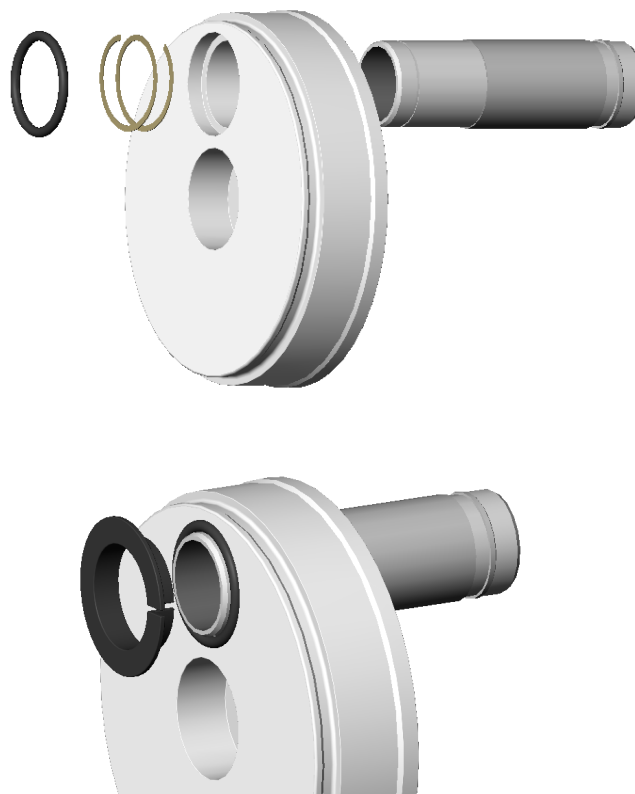
- (a) O-Seals - cracked, worn or cut areas.
- (b) Feed Concentrate Port – bent, distorted or corroded.
- (c) End Cap – material cracked, worn or locating screw threads damaged
- (d) Retaining Rings – bent, distorted or corroded.
- (e) Cap Head Screws - bent, corroded or threads damaged.
- (f) Hub - cracks or scratches in sealing areas.
- (g) Adaptor - cracks or scratches in sealing areas.
- (h) Spiroloc Circlip - distorted or broken.

Components which show any of the above should be replaced.

1.3.2 CORROSION - Examine metal components for evidence of corrosion which might affect structural performance. Pay attention to the segmented Retaining Ring set. Components which cannot be restored to the 'as new' condition should be replaced.

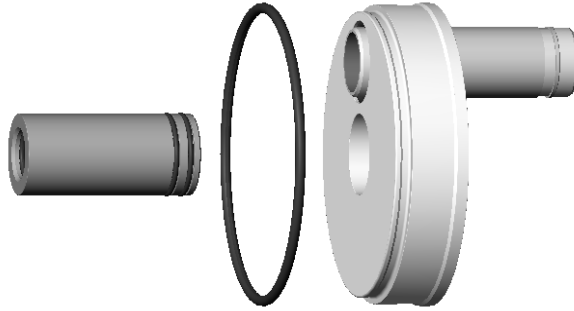
NOTE: It is recommended that O-Seals are replaced every time the end cap is rebuilt.

1.3.3 Push the Feed Concentrate Port through the off-centre hole in the End Cap. Fit the Spiroloc Circlip and port O-Seal. Use glycerine to aid assembly of the seal into position and press home the O-Seal to its most rearwards position using an appropriate tool (e.g. part number 1894 – split collet). Do not use the blade of a screwdriver.





1.3.4 If the Hub to End Cap was separated earlier then assemble the two items using plenty of glycerine lubricant and using a twisting motion to ease fitting. New O-Seals must always be used.



NOTE: Lubricate the O-Seals with Glycerine. Do not use grease as this may impair the performance of the membrane elements.



1.4 LOADING MEMBRANES

Note: This Section is provided as a Guide only, reference should be made to the element manufacturers recommendations for loading.

1.4.1 UNLOADING

- (a) Ensure system is NOT pressurised before starting work.
- (b) Remove both end caps from vessel.
- (c) Remove Thrust Ring and Adaptors from vessel.
- (d) Remove element from vessel following element manufacturers recommendations.

1.4.2 CHECKS BEFORE LOADING

- (a) Check the inside of the vessel for debris which may scratch the vessel. Remove any that is found by flushing with water or by using a clean cloth. Stubborn debris which adheres to the vessel may be removed by lightly polishing the area with waterproof silicone carbide paper. Use 400 Grade (fine) to start with and finish with 600 Grade (very fine). It will help to moisten the grit paper with water during use. Avoid continuously rubbing the same spot in the same direction. Afterwards remove any debris with water or by using a clean cloth.
- (b) Check that there are no sharp edges to the membrane element which could scratch the vessel. Contact the element manufacturer if these cannot be easily removed.
- (c) Check the element brine seal for wear and or cuts. Consult the element manufacturer for spares and advice.

NOTE: Sharp debris may scratch vessel bore. This should be removed before unloading elements.

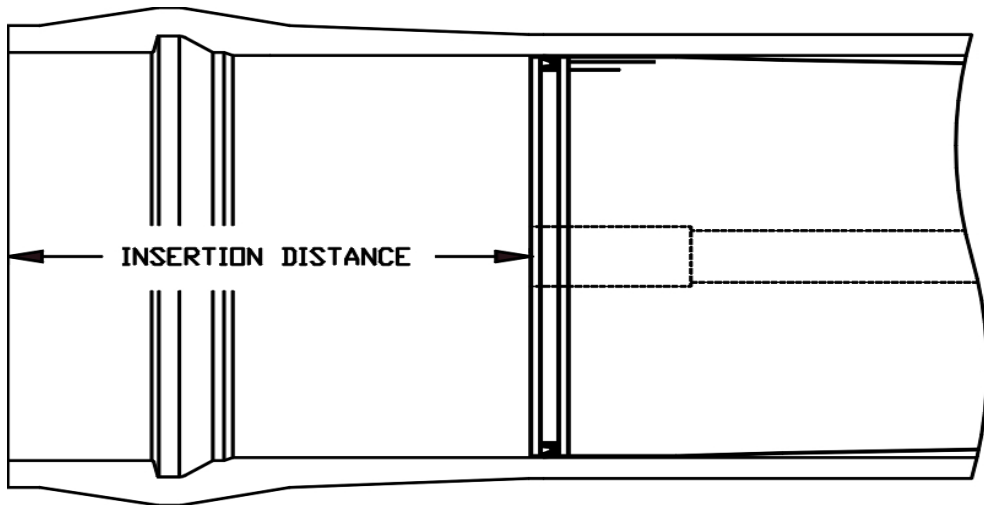
NOTE: Fine grade Scotchbrite may be substituted for waterproof silicone carbide paper.

1.4.3 LOADING

- (a) Lubricate the inside of the vessel with glycerine. If this is not available then flood vessel with clean water.
- (b) Check with the element manufacturer concerning the position of the brine seal. Normally this is placed on the upstream end of the element with the recessed part of the seal pointing upstream.
- (c) Push the elements into the vessel from the upstream end.
- (d) As each element is loaded insert the interconnector. To ease insertion glycerine should be applied to the O-seals.
- (e) Care should be taken to ensure that the weight of the element is not taken on the interconnectors during loading.

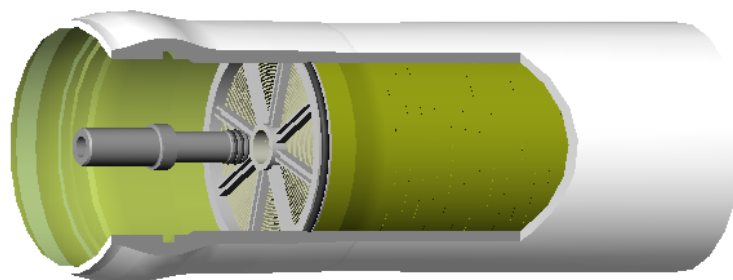
(f) The final element should be inserted the following distances in from the end of the vessel.

Vessel Type	Element Insertion Distance	
	MIN	MAX
8" 300 psi End Port	222 mm	247 mm



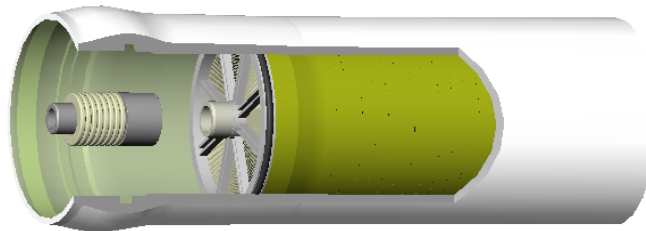
(g) If the elements are pushed too far then continue pushing until the first element emerges from the other end of the vessel. Take care to support its weight as it emerges.

(h) Fit the Adaptors provided with the vessel end cap to the core tube of the elements at both ends.



- (i) If the element is of the spigotted type - i.e. has a core tube which is proud of the face of the element, then Shims may be required to ensure that the element remains connected to the pressure vessel end fitting. These must be placed between the Adaptor and the Hub at the upstream end only - i.e. at the opposite end to the Thrust Ring.

The Shim is a solid plastic washer: - OD 55mm; ID 33mm, by 5mm thick. A maximum of 8 at the upstream end of the vessel may be used.

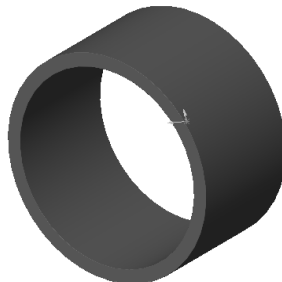


NOTE: Shims reduce wear on O-Seals by controlling the amount of free movement available to the element stack. They can be fitted on all element types but are only supplied for 'spigotted' element applications.

NOTE: Adaptors must be fitted to both ends of the stack of elements. Catastrophic failure of the product line can occur if adaptors are not fitted and pressure is applied.

The required number of shims may vary between any two vessels loaded with elements due to tolerance build up, each will require measuring to find the exact number. The ideal situation is to have a working float of 0.2" to 0.4" (5-10mm) at the upstream end of the vessel to allow for future thermal expansion and contraction. The best method of achieving this is to fit the maximum number of shims (8 at 0.2" thickness) and to keep subtracting shims one at a time until the retaining ring segments fit into the groove in the vessel. Finally subtract one more shim to ensure a safe float of 0.2"-0.4".

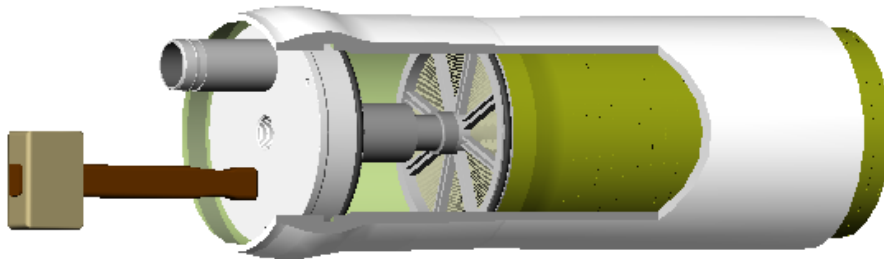
- (j) Normally only one Thrust Ring is provided per vessel the correct location being at the downstream end of the vessel. The design of Adaptor and Thrust Ring ensures even loading over the face of the element.



NOTE: Incorrect location of the Thrust Ring will damage the membrane elements.

1.5 CLOSING VESSEL

- 1.5.1 Check the inside of the vessel for debris which may scratch the vessel. Remove any that is found by flushing with water or by using a clean cloth. Stubborn debris which adheres to the vessel may be removed by lightly polishing the area with waterproof silicone carbide paper. Use 400 Grade (fine) to start with and finish with 600 Grade (very fine). It will help to moisten the grit paper with water during use. Avoid continuously rubbing the same spot in the same direction. Afterwards remove any debris with water or by using a clean cloth.
- 1.5.2 Lubricate the vessel inside surfaces with glycerine.
- 1.5.3 Lubricate the assembled end cap with glycerine, particularly the large 8" diameter O-Seal.
- 1.5.4 Insert the end cap squarely into the Vessel Body sufficient to allow the segmented Retaining-Rings to be inserted fully into the groove in the end of the vessel. If the end cap is difficult to push into the vessel then use the wooden shaft of a hammer (of appropriate type – see Section 1.1) to tap it into position.



NOTE: If the end fitting is inserted at an angle ie not squarely then there is a risk that the large end plate seal may come off - resulting in seal damage and leaks on start up.

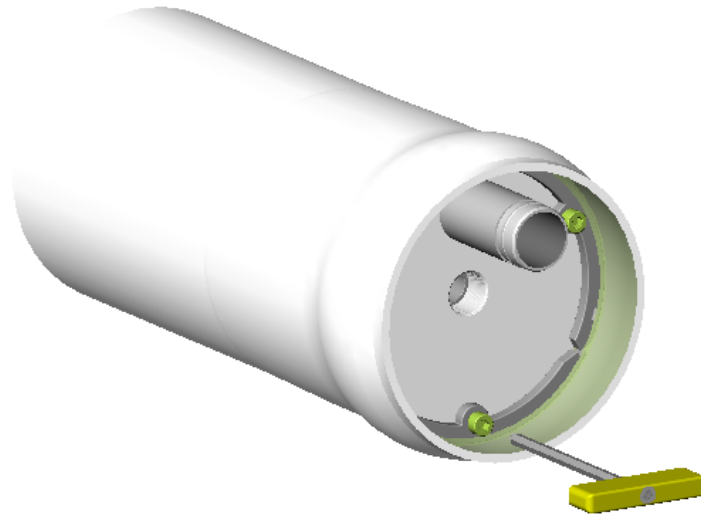
NOTE: Fine grade Scotchbrite may be substituted for waterproof silicone carbide paper.

NOTE: Do not use excessive force to insert the end cap. A light tap is sufficient.

If the end cap cannot be easily inserted then the following checks should be carried out.

- (i) Lubricate vessel surfaces with more glycerine and try again.
- (ii) The elements may have been pushed too far, proceed as follows:
Remove large 8" diameter O-Seal from end cap.
- (iii) Without the large O-Seal no effort should be required to insert the end cap, if there is still insufficient space to insert the Retaining Rings then the elements have been pushed too far during loading. Remove the last element by pushing it through the vessel taking care to support its weight as it emerges. Refer to Section 1.4 'Loading Membrane Elements' for further information.

- 1.5.5 With the end cap in place, insert one of the three segmented Retaining Rings and fix with one of the three Cap Head Screws. Do not tighten yet, leave loose as this will make for easier location of the remaining Retaining Rings. Put both of the remaining Retaining Rings into position before inserting the remaining Cap Head Screws. Finally tighten hand-tight up to a maximum torque of 8Nm.



NOTE: Remember to refit all O-Seals, Thrust Ring and insert Adaptors into the central core tube of the first and last element in the stack.

NOTE: A partially or badly assembled pressure vessel is dangerous. Carry out visual inspection on vessel to check compliance with these instructions. Check working area for any items left unassembled.



SECTION TWO

INSTALLATION

2.1 HANDLING

2.1.1 Vessels may be stored horizontally in any warehouse where the temperatures are as follows:

Maximum 120°F (49° C)

Minimum 32°F (0° C)

2.1.2 DO NOT subject the vessel to sharp blows or impacts as this may damage the vessel wall.

2.1.3 DO NOT use the ports which project beyond the vessel as lifting or manoeuvring aids.

2.1.4 DO NOT scratch the vessel inside wall.

2.1.5 Slings wrapped around the vessel wall and suspended from the forks of a fork lift truck are safer and more stable than using forks alone.

2.1.6 Forks should always be padded before being brought into contact with any part of the vessel body.

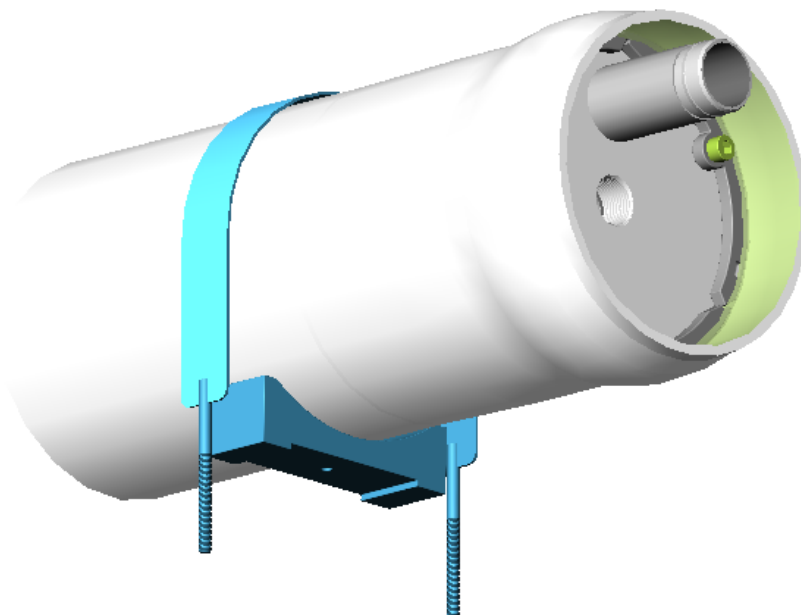
VESSEL DAMAGE:

This should be reported to the shipping company and Phoenix Vessel Technology Ltd.

2.2 VESSEL SUPPORT POSITION

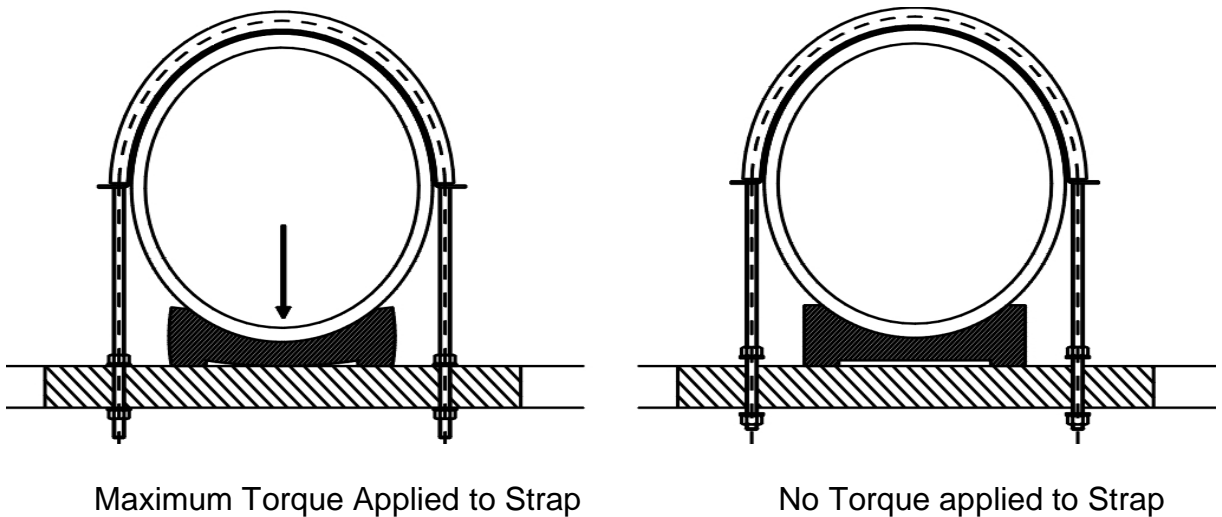
The bending stresses generated in a long pressure vessel can be considerable and should not be ignored. Careful choice of support position can minimise bending stresses to an acceptably low level. Always follow instructions stated on the Assembly Drawing for each particular vessel design and length ordered. These recommendations are based on static loading only.

No. of 40" Elements	No. of Supports	Distance between Supports (mm)		Distance between Outer Supports (mm)	
		Max	Min	Max	Min
1	2	1100	700		
1.5	2	1400	1000		
2	2	1800	1300		
3	2	2400	1800		
4	2	2950	2400		
4.5	2	3200	2800		
5	2	3450	3150		
6	2	4000	3800		
3	3			2400	1800
4	3			3250	2400
4.5	3			3700	2800
5	3			4150	3150
6	3			5000	3800
7	3			5800	4850
7.5	3			6200	5350



2.3 MOUNTING AND CONNECTING TO VESSELS

2.3.1 Mount vessels in a symmetrical manner using the support Saddles provided on horizontal surface at the recommended support position and tighten Straps to eliminate movement, do not tighten to more than the maximum drawing specified torque. The base of the elastomeric Saddles supplied with the pressure vessel housing has a gap of 0.12" (3mm) at its midpoint when unloaded. This gap reduces when the vessel is placed on the Saddle and the Straps tightened. A quick visual check that correct Strap torque has been applied can be made by checking to see whether the gap, originally 0.12" (3mm) just closes at its midpoint only. If the air gap is not visible at all then the Straps should be loosened off until the Saddle contacts the support at its midpoint only.



2.3.2 Provide pressure relief device. This should be set to no more than 105% of design pressure.

2.3.3 Allow for an expansion of 0.6mm per metre length of vessel at design pressure.

2.3.4 Victaulic clamps used for connection to vessel should be assembled tightly with bolt pads of clamp halves metal to metal.

NOTE: Excessive torque applied to the straps may damage the vessel wall and cause the strap nut to seize onto the threaded portion.



SECTION THREE

OPERATION

3.1 CORROSION

Whilst every effort has been taken to ensure that end fittings have adequate corrosion resistance it is the responsibility of the purchaser to assess that the materials offered are suitable for the specific corrosion environment.

Alternate materials are available with enhanced corrosion resistance, contact Phoenix Vessel Technology for advice.

End fittings should be maintained dry and free from corrosion. Vessel leaks should be investigated and corrected.



3.2 OPERATING CONDITIONS

DESIGN SPECIFICATION

Internal Diameter:	To fit any 8" nominal diameter element.
Length:	Up to 300" of membrane elements.
Working Fluid:	Water (brackish or seawater).
Design Pressure:	300 psi (20.7 bar).
Test Pressure:	upto 450 psi maximum for up to 15 minutes.
Factory Test Pressure:	1.5 times design pressure for 15 minutes or 1.1 times design pressure for 15 minutes at the customers request.
Design Temperature:	1 to 45 °C (33 to 113°F). Vessel contents must not be allowed to freeze solid.
Expansion:	Length 0.6 mm per metre length of vessel at design pressure. Diameter 1.2 mm per metre of vessel diameter at design pressure
Vacuum condition:	Down to -14.5 psi (0 bar absolute).
Support Position:	2 supports for 1 to 6 (40") elements. 3 supports for 7,7.5 (40") elements, and any length supported outside of the recommended support range (refer to 'Vessel Support Position' Section 2.2 of this User`s Guide). This is the minimum static requirement – additional supports maybe required for applications involving flexing of the support structure housing the vessels or where high accelerations or decelerations maybe experienced.

NOTE: The standard materials of construction may not be compatible with cleaning and preserving fluids. See Section 3.4 for further information. If in doubt, submit request to Phoenix Vessel Technology Ltd.

NOTE: The vessel should not be allowed to freeze solid. This will damage the vessel wall and make replacement necessary.



3.3 SAFETY PRECAUTIONS

Fibreglass reinforced pressure vessels will provide years of safe service if properly installed and maintained. This section is for guidance only and should be used in conjunction with the recommendations in the previous sections. Attention is drawn to the `NOTES: ` located at the bottom of the page which highlight potential problems areas and safety recommendations.

3.3.1 Provide pressure relief device. This should be set to no more than 105% of design pressure.

3.3.2 Before pressurisation visually check that the segmented Retaining Rings are in position and secured by the three Cap Head Screws.

3.3.3 DO NOT stand in line of end fitting while pressurisation takes place.



3.4 CHEMICAL COMPATIBILITY

The following is a guide to material compatibility. The test conditions were based on relatively short term exposure - 4 weeks in the following solutions at 10-15 deg C. The samples were exposed in the un-stressed condition - in other words NOT what happens to a pressure vessel in service.

UN-STRESSED RESULTS:

		GRP	ST ST	POM	PETP	UPVC	NBR	EPDM
Hydrochloric	7.30 %	2	2	1	1	1	1	1
Sulphuric	20.00 %	2	1	2	1	1	3	1
Ortho Phosphoric	20.00 %	1	1	3	1	1	3	1
Nitric	1.00 %	1	1	1	1	1	1	1
Nitric	20.00 %	2	1	3	1	1	3	1
Sodium MetaBisulphate	0.01 %	1	1	1	1	1	1	1
Sodium MetaBisulphate	0.08 %	1	1	1	1	1	1	1
Sodium MetaBisulphate	2.00 %	1	1	2	1	1	1	1
Sodium Hypochlorite	12.00 %	1	1	1	1	1	3	1
Potassium Hydroxide	2.80 %	3	1	1	3	1	1	1
Sodium Hydroxide	4.00 %	1	1	1	2	1	1	1

STRESSED RESULTS (Application of working pressure):

		GRP	ST ST	UPVC	NBR	Comment
Nitric Acid	10 %	1	1	1	1	14 day test – 200,000 applications to working pressure. No leaks and no strain-corrosion evident.
Nitric Acid	(Conc)	3	2	1	3	4 day test – 30,000 applications to working pressure. Vessel bore burnt away. NBR seals turned to black powder. Stainless steel blackened.
Citric Acid	20%	1	1	1	1	24 day test – 200,000 applications to working pressure. No leaks and no strain corrosion evident.
Ammonium Hydrogen Fluoride	(5 %)	3	1	1	1	18 day test – 200,000 applications to working pressure. Vessel leaking through wall from cracks starting from bore. STRAIN CORROSION

Key:	Abbreviations:
1 = No effect	GRP Glass Fibre Exposy Resin used in manufacture of pressure vessel housings
2 = Slight effect (eg colour change)	ST ST Stainless Steel 316
	POM Polyoxymethylene usually referred to as 'Acetal', 'Delrin' and 'Kematal'
	PETP Polyester Terephthalate (not to be confused with PE – polyethylene)
3 = Destroyed (or embrittled)	UPVC Unplasticised Polyvinyl Chloride
	NBR Nitrile Rubber
	EPDM Ethylene Propylene Rubber

Note: Items listed as Category 2 maybe liable to strain-corrosion under application of working stress and chemical exposure.



MEMBRANE CLEANING SOLUTIONS

Ammonium Hydrogen Fluoride (also known as Ammonium BiFluoride) is a glass 'etchant' and will destroy a fibreglass vessel from the inside out - the fiberglass outer wrap of the membrane elements may also be weakened. Contact with this agent should be avoided. This chemical is suggested as a means of removing silica fouling (SiO_2) of membranes. If silica fouling requires the use of this chemical then the membrane elements must be removed for cleaning in a purpose built cleaning vessel.



SECTION FOUR

APPENDIX

4.1 SPARE PARTS LIST

For part numbers and descriptions refer to the relevant Technical Information Sheet.