



LENNTECH

**4" SIDE PORT
PRESSURE VESSEL**

**TECHNICAL
MANUAL**

LENNTECH

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Introduction

BEL, founded in 1966, specializes in the design and manufacture of a variety of products made from advanced composite materials. With over 40 years of experience, the company has developed and mastered the innovative technologies necessary to manufacture the highest quality composite products. Combining innovation, technology, responsibility and dedication, our goal is to become the leader in providing commercial and industrial composite vessels for our clients needs.

BEL pressure vessels are manufactured from filament wound fiber reinforced plastic (FRP), wound over precision mandrels, using a superior epoxy resin, which results in the ultimate combination of physical strength and an ultra smooth inside surface. Vessels are tested according to the requirements of ASME code section X, the internationally recognized standard for pressure vessel construction.

BEL holds ISO 9001 quality systems certification, and its quality assurance is also approved for in-house final inspection by many of its customers.

The BEL family of pressure vessels is designed to be used as housings for all 4" ,8" ,9" and 16" spiral-wound Reverse Osmosis (RO), Nanofiltration (NF) and Ultra filtration (UF) membrane elements.

The pressure vessels are manufactured in different configurations, according to the required operating pressures, filtration type, and piping layout. In order to enhance interchangeability and facilitate the use and maintenance of the vessels, the utilization of identical parts and sub-assemblies has been maximized throughout the design of the vessel. For better performance and longer service life, each model is manufactured from the highest quality and highest performing materials of construction.



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Chapter 1- Safety precautions

- i. BEL pressure vessels are designed for high pressure operations. Improper installation, operation service or maintenance may cause severe damage to property, physical injury or death.
- ii. BEL pressure vessels are designed for water treatment only.
- iii. **PRESSURE AND TEMPERATURE DESIGN LIMITS** - Operation of a vessel outside the design limits will make void the warranty and may result in vessel fatigue with possible eventual explosive head failure. Although each vessel is tested at 110% of the design pressure **LONG-TERM OPERATION ABOVE DESIGN PRESSURE MUST BE PREVENTED**. Permeate port pressure **MUST NOT EXCEED 125 psi (8.6 bar)**.
Vessels should **NOT BE CONTINUOUSLY OPERATED AT TEMPERATURES ABOVE 120°. (49° C)**.
- iv. The pressure vessel should not be use as a support. Piping manifolds and other fittings should be properly designed system framework. **OPERATING PERSONNEL SHOULD BE DISCOURAGED FROM APPLYING UNDUE FORCE TO ANY FITTINGS CONNECTED DIRECTLY TO A PRESSURE VESSEL.**
- v. Only qualified mechanics, experienced in working with high pressure hydraulic systems, should be allowed to disassemble or assemble the vessel.
- vi. Regularly inspect the system so as to ensure that the various components have not deteriorated or been damaged. Replace any faulty component, make sure the reason for the fault has been found and fixed as well.
- vii. Make sure that vessels and associated pipe systems are fully depressurized before attempting any service or maintenance operation.
- viii. Be careful not to scratch the inside wall of the shell, especially at the inner sealing area near the groove.
- ix. Corroded parts may cause difficulties in removing the head or other components. Do not try to force remove components before all visible signs of corrosion have been eliminated.
- x. Never attempt to repair or disassemble the feed/concentrate port in a side port vessel without consulting BEL.
- xi. Inspect end closures regularly; replace components that have deteriorated and correct causes of corrosion.
- xii. Do not tolerate Leaks, or allow end closures to be routinely wetted in any way.

Chapter 2 - Installation notes

- 2.1 Provide adequate room for serving at both ends of vessel. Elements are installed from the upstream end, pushed through towards the downstream end and eventually removed from the downstream end.
- 2.2 Make sure that the vessel is horizontally installed on support saddles.
- 2.3 The vessels must not be rigidly clamped in place, mounting design must allow for both radial and axial expansion (typically up to 0.5 mm radial and up to 2-3 mm axial). Restriction can result in damage to the vessel and other system components.
- 2.4 Straps should be tightened enough to hold the vessel onto the support pads, but never so tightly as to restrict expansion.
- 2.5 A flexible piping connection should be provided in order to prevent unwanted loads transfer from the manifolds to the permeate connection and to permit decoupling the header from the vessel.
The recommended permeate port connection is a U-bend pipe with flexible connections at each end.
- 2.6 The piping system must be connected to the ports using flexible connectors in order to allow relative movement of the vessels and the piping system. (Victaulic or equivalent connections are recommended).

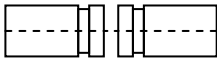
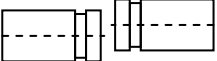
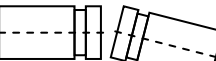
Side Port	 Spacing [mm]- X	 Max Offset* [mm]	 Max Angle [Deg]
1"	2 + 0.5	3	2.5

Table 2.1 - Victaulic maximum offset

Chapter 3 - Component list

3.1 BEL 4" pressure vessel - 300/450 psi side port assembly

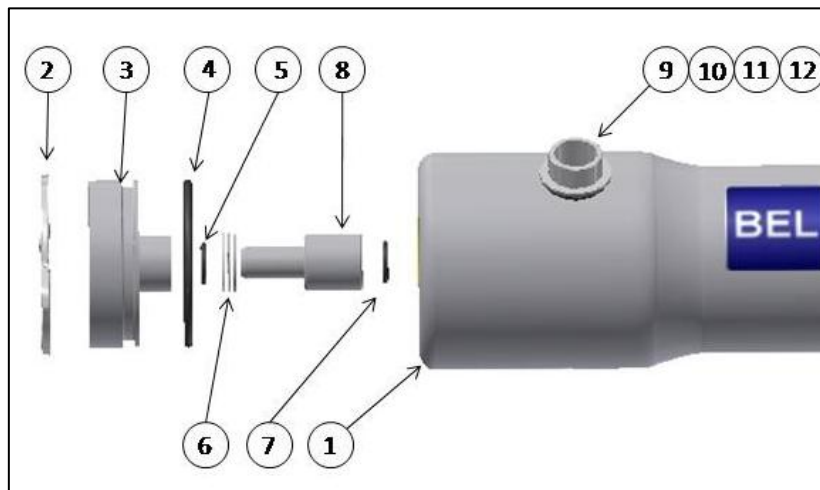


Fig 3.1 - BEL 4" 300/450 PSI head assembly (ends are identical)

ITEM	PART NUMBER	QTY	DESCRIPTION	MATERIAL
Vessel				
1	41300-1*	1	Body of pressure vessel	Glass/Epoxy
Head assembly				
2	55410208	2	Retaining ring	Stainless steel
3	003-400-0005	2	Base plate	Engineering plastic
4	55412360	2	Seal for base plate	EPDM
5	55412367	2	Seal for adapter	EPDM
6	55412377	0-6	Disk spacer	Engineering plastic
7	As required	2	Membrane seal	EPDM
8	As required	2	Adapter	Engineering plastic
Feed/Concentrate port assembly				
9	009-106-0450	1-4	F/C port 1"	Stainless steel
10	014-100-0505	1-4	Seal for F/C port	EPDM
11	006-112-1202	1-4	Disk for F/C port	Stainless steel
12	011-100-1202	2-8	Retaining ring	Stainless steel
Vessel support parts - optional -				
13**	55410246	2	Strap assembly	Stainless steel
14**	55410352	2-3	Saddle	Engineering plastic
* For working pressures - 300/450. Number of elements can vary between 1-6 for membrane length of 40", or 1-12 for membrane length of 21".				
** items not shown in the drawing assembly				

Table 3.1 - BEL 4" 300/450 PSI components list



3.2 BEL 4" pressure vessel - 600/1000/1200 psi side port assembly

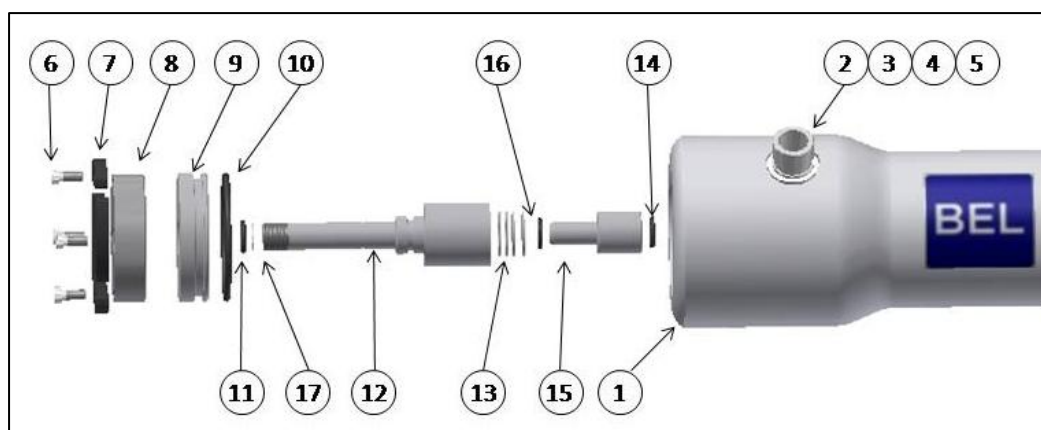


Fig 3.2 - BEL 4" 600/1000/1200 PSI head assembly (ends are identical)

ITEM	PART NUMBER	QTY	DESCRIPTION	MATERIAL
Vessel				
1	411000-1*	1	Body of pressure vessel	Glass/Epoxy
Feed/Concentrate port assembly				
2	009-107-1200	1-4	F/C port 1"	Super duplex stainless steel
3	006-116-1202	1-4	Disk for F/C port	Stainless steel
4	014-100-0505	1-4	Seal for F/C port	EPDM
5	011-100-1202	2-8	Retaining ring for F/C port	Stainless steel
Head assembly				
6	55412349	8	Socket screw	Stainless steel
7	55410230	8	Lock	Aluminum
8	003-420-1200	2	Base plate	Aluminum
9	013-400-1200	2	Sealing plate	Engineering plastic
10	55412360	2	Seal for sealing plate	EPDM
11	55412363	2	Seal for permeate port	EPDM
12	008-400-1200	2	Permeate port	Engineering plastic
13	55412377	0-6	Disk spacer	Engineering plastic
14	As required	2	Membrane seal	EPDM
15	As required	2	Adapter	Engineering plastic
16	55412367	2	Seal for adapter	EPDM
17	55412369	2	Retaining ring for p.port	Stainless steel
Vessel support parts - optional -				
13**	55410246	2-3	Strap assembly	Stainless steel
14**	55410352	2-3	Saddle	Engineering plastic
* For working pressures - 600/1000/1200. Number of elements can vary between 1-6 for membrane length of 40", or 1-12 for membrane length of 21".				
** items not shown in the drawing assembly				

Table 3.2 - BEL 4" 600/1000/1200 PSI components list

Chapter 4 - Maintenance

4.1 - Head assembly

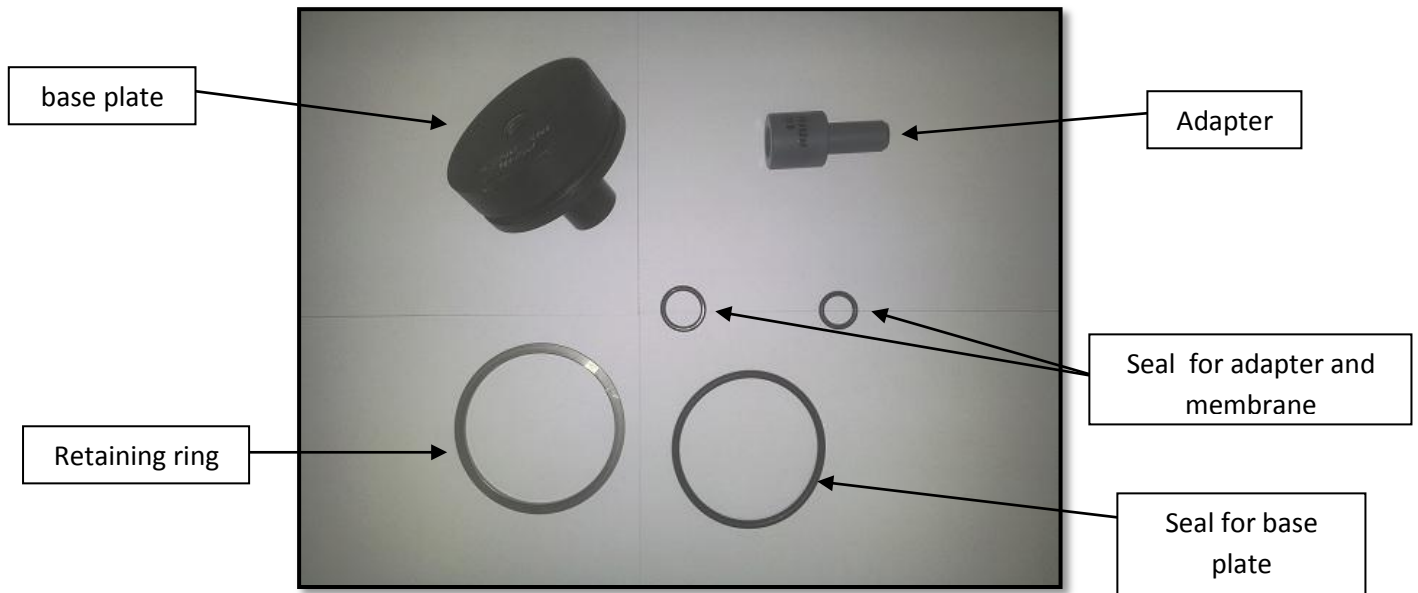


Fig 4.1 - bel 4" pressure vessel head component - 350/450 psi

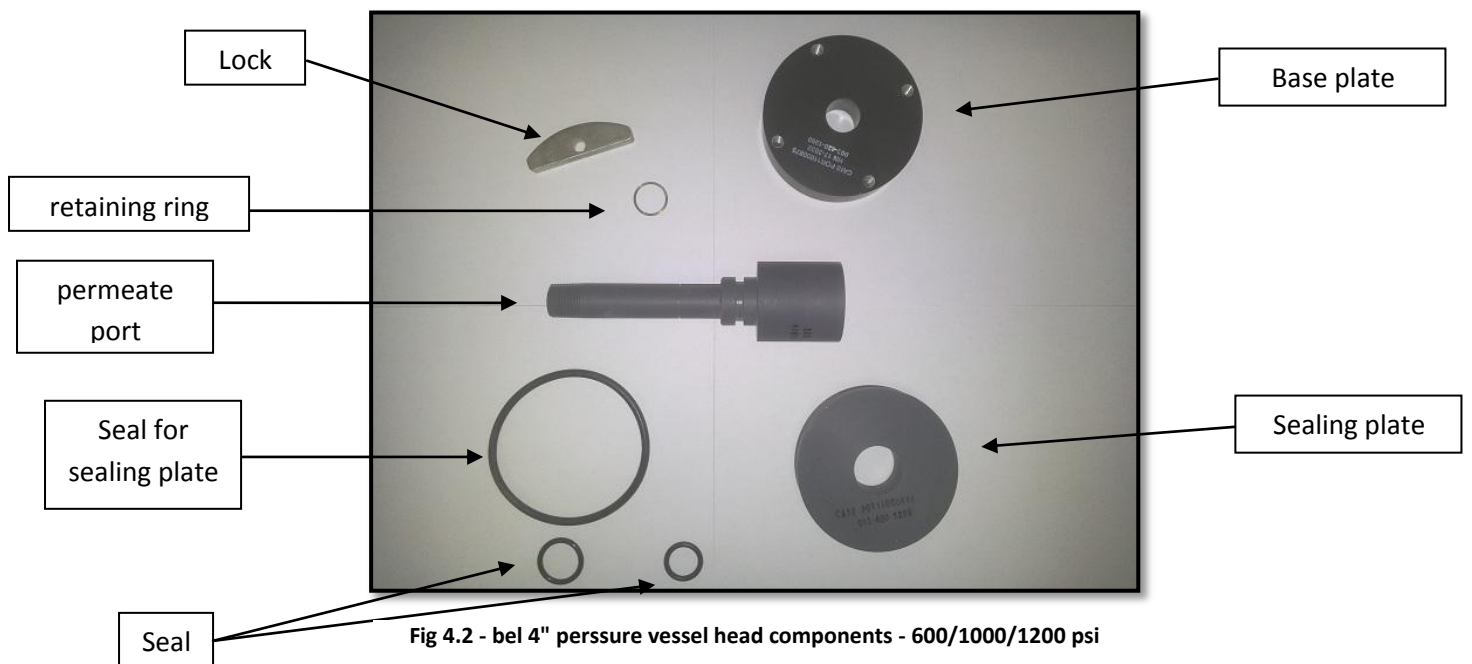


Fig 4.2 - bel 4" pressure vessel head components - 600/1000/1200 psi

4.1.1 - BEL 4" pressure vessel 300/450 psi

- a. Apply an even layer of lubricant on seals (Glycerin, Molykote 111 or equivalent). **if re-assembling is done , it is recommended to replace all seals.**
- b. Insert seal and adapter into base plate (Disk spacers may be required, see appendix 1).
- c. Assemble the base plate seal in base plate groove.
- d. Clean the groove area inside the vessel with a dry rag and apply a thin layer of lubricant.
- e. Place the assembled parts in the vessel and push it till the groove.
- f. Use an installation tool to strike base plate in place (till groove is exposed).
- g. Once the head assembly is in place, insert the retaining ring locker into the groove and run your finger around the retaining ring until it will fit in place (One can use a flat screwdriver instead).



a



b



c



d



e



g

Warning: Retaining ring must be properly installed. Failure to comply with this instructions may result in severe damage to property and/or physical injury.

4.1.2 - BEL 4" pressure vessel 600/1000/1200

- a. Apply an even layer of lubricant on the seals (Glycerin, Molykote 111 or equivalent). **if re-assembling is done, it is recommended to replace all seals.**
- b. Insert seal and permeate port into sealing plate.
- c. Place permeate port with sealing plate into base plate.
- d. Lock permeate port with designated retaining ring.
- e. Clean the groove area inside the vessel with a dry rag and apply a thin layer of lubricant.
- f. Place the assembled parts inside the vessel and push it through the groove.
- g. Use an installation tool to strike base plate in place (until groove is exposed).
- h. with head assembly in place, install four locking segments into the locking groove and secure each one of them with an Allen screw.
- i. visually inspect the locking segments installation to ensure that their position is correct between head disc and the vessel groove. Make sure that each lock is safely secured with its screw.



a



b-1



b-2



c



d



e



h

Caution! over- tightening may cause disassembly problems. it is recommended to apply an anti- seize compound onto screw threads to facilitate late assembly.

Warning: Locking segments must be properly installed. Failure to comply with this instructions may result in severe damage to property and/ or physical injury.



4.2 - Head disassembly

- a. **Pressure relieve** - Stop all pumps and relieve pressure.
- b. Disconnect all pipes from ports connecting vessel's heads with manifolds.
- c. **300/450 psi vessels** - Use a flat-end screwdriver. Insert the blade underneath the tab of the spiral retaining ring locker and pull out the end of the spiral. Pull the spiral's end towards the center of the head and outwards until the whole length of the spiral retaining ring has been extracted
600/1000/1200 vessels - Disassemble locking segments by using a screwdriver.
- d. Use a removal tool in order to remove head assembly from vessel. see appendix 2 for BEL's extractor.
- e. When disassembling is done, please refer to section 4.3 visual inspection for further maintenance actions.

4.3 Visual inspection

Once the head have been disassembled perform a visual inspection of the vessel head and fitting in order to locate any signs of corrosion or salt concentrations. If corrosion or salt concentrations are found follow these steps:

4.3.1 Component inspection

- i. Use a small wire brush to loosen any large deposits.
- ii. Place components in a shallow container of soapy water and scrub their surfaces with medium-grade Scotch-Brite until all corrosion is removed.
- iii. Rinse components with clear water.
- iv. Blow components dry with compressed air.
- v. Examine components for damage that may affect structural strength or sealing properties.

Note! DO NOT strike or apply excessive force on the ports to remove the vessel's head.

4.3.2 Vessel inspection

- i. If any case of deposit of foreign material has been discovered scrub the surface with a fine Scotch-Brite and a mild detergent solution, clean both ends of the vessel, up to 20 cm into the vessel.
- ii. If during inspection scratches are found on the inner surface of the vessel up to 15 cm depth, grind the area carefully with sand paper until it is smooth.

Note! if the vessel was in service for a long time, it may be more difficult to remove the head assembly.

4.4 Loading the membrane element

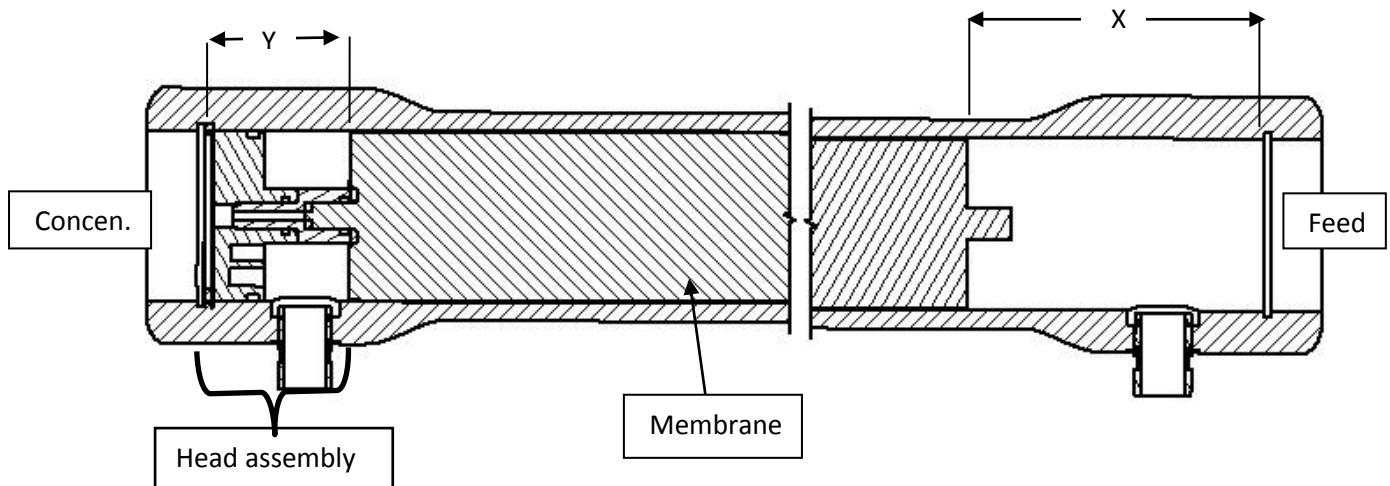
- | | |
|---|--|
| <ul style="list-style-type: none"> i. Flush the vessel with fresh water to remove dust and debris. ii. Insert Head assembly, without the O-ring into the downstream end of the vessel. iii. Install the segments of the support ring into the locking groove. iv. Inspect the membrane element surface to find any imperfections that could scratch the vessel bore element loading. If a defect is found, which cannot be easily corrected contact the element manufacturer. v. Apply a thin layer of lubricant to lubricate the inside of the vessel near the groove.
This will assist membrane element loading and reduce the risk of inadvertently scratching the vessel bore. vi. Install the brine seal on the upstream end of the membrane element so that the seal's open side faces upstream (if it is not already installed by the manufacturer). vii. Load the first element into the upstream of the vessel .Leave 10 cm of the element projecting out of the vessel to facilitate connection with the next element. viii. Apply a small amount of Lubricant onto the O-ring of the interconnector. | <ul style="list-style-type: none"> ix. Connect the interconnector to the projected end of the loaded element. x. Line up the next element and assemble it to the inter connector which is already on the first element. Carefully maintain element alignment during assembly, misalignment may result damage to the membrane and vessel parts. xi. Line up the next element and assemble it to the interconnector which is already on the first element. xii. Carefully push the two elements into the vessel until the second element is projecting from the vessel approximately 10 cm. Repeat the above steps until all membrane elements have been assembled. xiii. Calculate the correct shimming distance (see Annex 2) in order to avoid impact damage on the membrane and head parts during pressure drop. xiv. Insert the shimming spacers on the upstream head assembly (Membrane adapter) so that the sum of their lengths will be equal to the shimming distance. xv. Install the upstream head assembly as described in section 4.1. xvi. Remove the downstream head assembly and reassemble it with the O-ring. |
|---|--|

Appendixes

Appendix 1 - Shimming procedure

Shimming is needed in order to keep minimum membrane movement. **Apply shimming at the feed side only.**

First, make sure the membranes is fully pressed towards the brine side. Load the head assembly and the membranes. In order to check that the membrane is fully pressed against the brine side, pull out the head assembly and measure the distance between the membrane and the locker (See "Y" in the drawing below). This distance is equal to the total length of the head assembly (110 mm for 300/450 psi vessels, 135 mm for 600/1000/1200 psi vessels). It is important to mention that measuring of "Y" is an option and it's not mandatory. However it is very important* to make sure that the membrane is fully pressed before applying the shimming procedure.



Correct shimming can be achieved by using the following formulas:

For BEL 4" 300/450 psi:

Let X (see drawing above) be the distance between the groove and the membrane on the feed side. Measure this distance by using a caliber between the inner side of the locker and membrane.

$$\text{Shimming} = X - t_{\text{base plate}} - t_{\text{adapter}} - 2 = X - 75 - 35 - 2 \Rightarrow X - 112 \text{ [mm]}$$

$t_{\text{base plate}}$ - Thickness of base plate

t_{adapter} - Thickness of adapter

* Note: this process is highly recommended for vessels containing 3 membranes and above.



For BEL 4" 600/1000/1200 psi-

Let X (see drawing above) be the distance between the inner side of the locker and the membrane on feed side.

$$\begin{aligned} \text{Shimming} &= X - t_{\text{sealing plate}} - t_{\text{base plate}} - t_{\text{permeate port base}} - t_{\text{adapter}} - 2 \\ &= X - 23 - 25 - 52 - 35 - 2 \Rightarrow x - 137 \text{ [mm]} \end{aligned}$$

$t_{\text{sealing plate}}$ - Thickness of sealing plate

$t_{\text{base plate}}$ - Thickness of base plate

$t_{\text{permeate port base}}$ - Thickness of permeate port base

t_{adapter} - Thickness of adapter

After installing the shimming, a space of 1 mm to install the retaining ring locker / locker shall remain. In case of extra space or too little space, remove or add spacers respectively until receiving a satisfying result.

Appendix 2 - BEL puller for 4" pressure vessel

This tool designated for head assembly extraction. before disassembling make sure internal pressure has been unloaded.

1. Kit assembly:

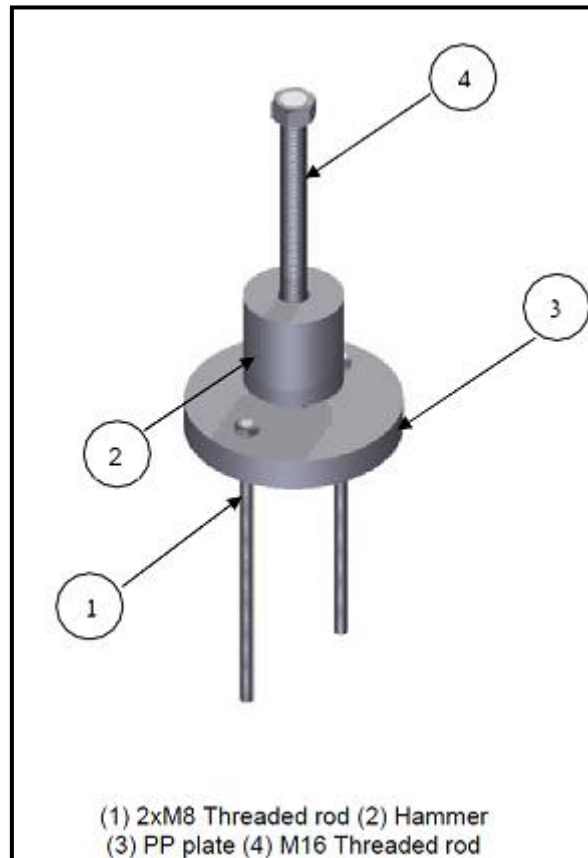
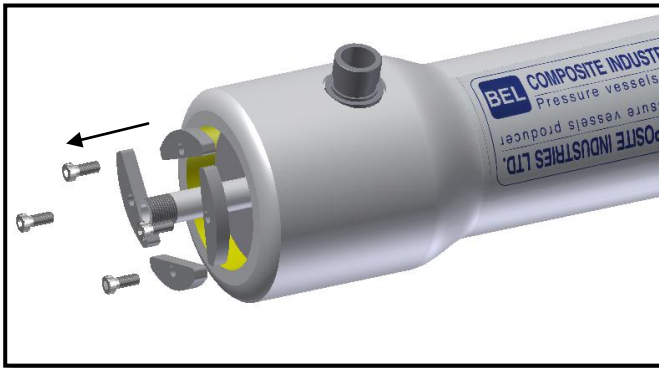


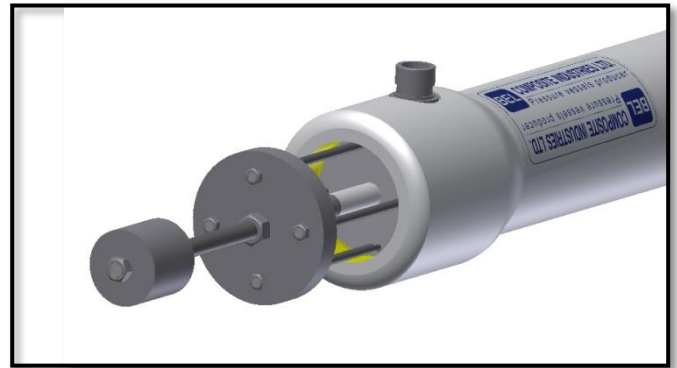
Illustration of puller assembly

Make sure to assemble the puller as shown in illustration above.

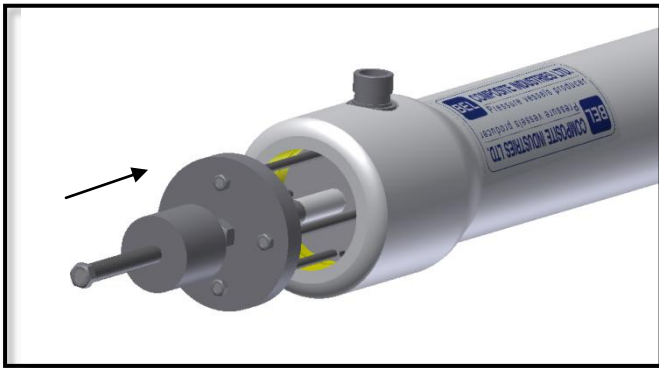
2. Extracting head assembly (See demonstration images below) -
 - a) Remove bolts from locker and take out the lockers.
 - b) Screw threaded rod (part 1 in illustration) in base plate thread holes.
 - c) Move hammer (part 2 in illustration) back and forward against the nut in order to extract the head assembly.



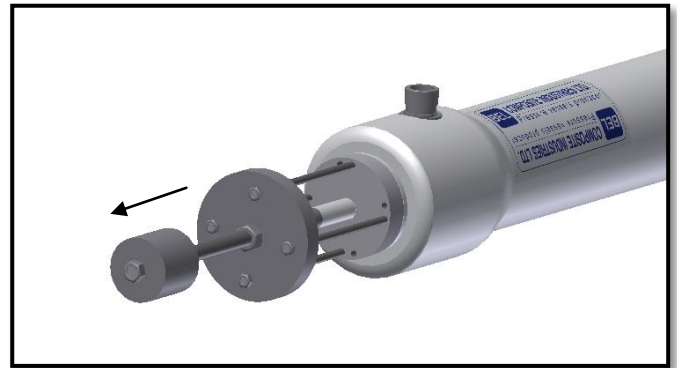
A



B



c - hammer in



c - hammer out



Extraction of head assembly



Appendix 3 - O-Ring replacement and scratches treatment procedure

1. Preparations

Please prepare the following items before procedure:

- i. New intact O-Ring seal.
- ii. Clean cloth.
- iii. Lubricant.
- iv. BEL Pusher-Puller (optional).

2. O-Ring Replacement procedure

- i. Remove head assembly.
- ii. Clean vessel internal surface at sealing area (O-Ring area) with clean damp cloth.
- iii. Ensure vessel sealing area is smooth and free of scratches. See next procedure for scratch treating.
- iv. Assemble the head assembly and apply full and reach layer of lubricant on seals, vessel's groove and vessel's sealing area.(Ensure the base plate/sealing plate O-Ring groove is clean and free of scratches).
- v. Install the head assembly.

3. Scratches treatment procedure

- i. Clean vessel internal surface at sealing area (O-Ring area) with clean damp cloth.
- ii. Locate the scratch at the O-Ring sealing area. Scratches out of this area will not cause leaks, therefore will not be treated.
- iii. Grind out the scratch using Extra-Fine sand paper (P400) until scratch is flat and smooth. DO NOT grind deep into the vessel, this might cause permanent damage to the vessel.

Note: In case of deep scratches or layers de-lamination please consult BEL engineering department.