GLAND DESIGN AND ASSEMBLY PROCEDURE FOR STEP PISTON-MOUNTED SEALS

Technical Report
TR-6.2 **(Rev. B)**

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Bal Seal Engineering is certified to ISO 9001 and TS 16949

1.0 INTRODUCTION: STEP PISTON-MOUNTED BAL SEAL® SPRING-ENERGIZED SEALS

NOTICE: Assembly of seals into stepped piston glands causes permanent deformation of the seal ring material and reduces sealing ability and life.

1.1 Construction Materials

Only PTFE and PTFE-filled compositions are suitable materials for step piston Bal Seal® assemblies. After inserting the seal into the groove, the resizing process forces the seal jacket back into shape.

Certain seal jacket materials lack cold flow properties, which is a characteristic of plastic to change shape when subject to a constant force. Materials that lack cold flow properties and cannot be used for groove design Bal Seals include: UHMWPE (UPC-10, UPC-15, UPC-16, UP-30, and UP-40,) P-40, and P-41 materials.

However, PTFE is soft and will 'cold flow' under pressure, making it an ideal material for these applications. Therefore, PTFE and PTFE-filled compositions are the only appropriate material for step piston seal assemblies.

1.2 Assembly and Re-sizing

Proper installation of Bal Seals is important. Sharp edges, burrs, dents, and irregularities on the assembly tools can mark, scratch, or deform the seal surface, reducing sealing ability.

We highly recommend using a two-piece (split) gland. If use of a two-piece gland is not possible, we can provide assistance with seal installation. This report describes the installation procedures and the data for fabricating the assembly tools.

We do not manufacture assembly tools, but we will provide assembly-detail drawings for them. Tool performance is not guaranteed, and the user must identify tool suitability for their application.

A number of factors affect seal assembly and performance; seal material, seal cross-section, seal diameter, spring force, assembly tool material, and fluid pressure.

Please contact the Bal Seal Engineering Technical Sales Department if you require assistance with seal installation.

2.0 MOUNTING OPTIONS CHART - DESIGNS AND FEATURES

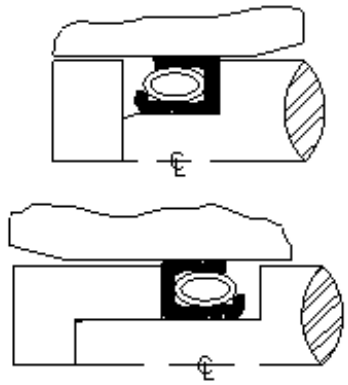
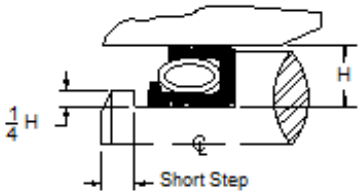
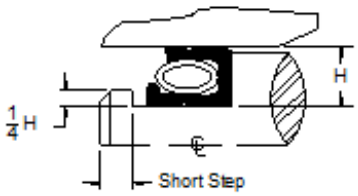
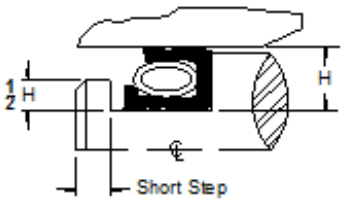
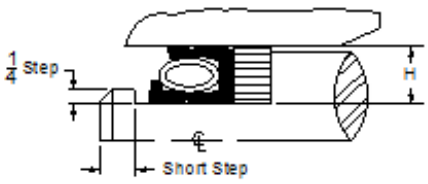
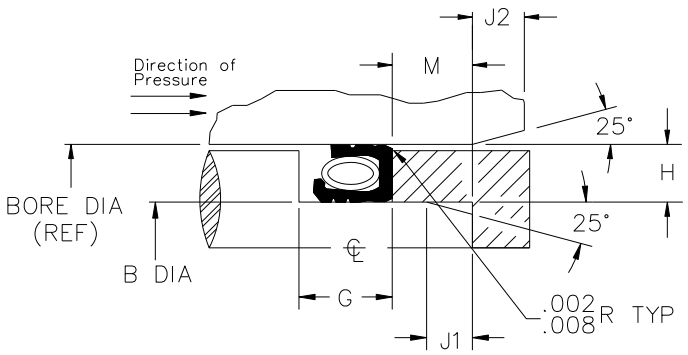
Designs		Features	Page
Split Piston Manual Assembly		• Best sealing ability • Easy to assemble into gland • No assembly tools required • Recommended	5
Step Piston (¼ H) Manual Assembly		• No assembly tools required • 1/4H Step must use P-series seal	6
Step Piston (¼ H) Assembly Tools Required		• Must use P-series seal for 1/4 H step • Asssembly and sizing tools required • Applicable for diameters from .216 in ID (5.5 mm)	7
Step Piston (½ H) Assembly Tools Required		• Larger radial step for better retention • Applicable for diameters from .312 in ID (8.0 mm)	7
High Pressure Step Piston (¼ H) Assembly Tools Required		• Pressure to 10,000 psi • Must use P-series seal • Assembly and sizing tools required • Applicable for diameters from .216 in (5.5 mm) • Backup ring made from PTFE materials	8

CHART #1

Note: We do not recommend solid pistons because stretching the Bal Seal® during assembly may negatively affect its performance.



5 = 1/8 (0.125/0.127)	0.183/0.193	0.025± 0.003	0.125± 0.008	0.187	0.310
6 = 3/16 (0.187/0.189)	0.263/0.273	0.030± 0.003	0.187± 0.010	0.500	0.380
7 = 1/ 4 (0.250/0.252)	0.351/0.366	0.035± 0.003	0.250± 0.012	1.500	0.455
8 = 3/ 8 (0.375/0.377)	0.523/0.543	0.045 ± 0.004	0.375 ± 0.015	4.250	0.530
9 = 1/2 (0.500/0.502)	0.686/0.711	0.060 ± 0.004	0.500 ± .020	5.000	0.600

CHART #2

3.2 Stepped Gland (1/4) – P-Series (No Tools Required)

3.2.1 Description

The P-series seals are designed to be mounted on the ¼ H stepped piston gland. The P-series has no static lip chamfer for improved seal retention, with a Dynamic scraper lip design. P-series Bal Seals® withstand pressures to 3,000 psi (211 kg/cm^2.) Figure 3 and Chart #3 show dimensions for the P-series ¼ H gland design.

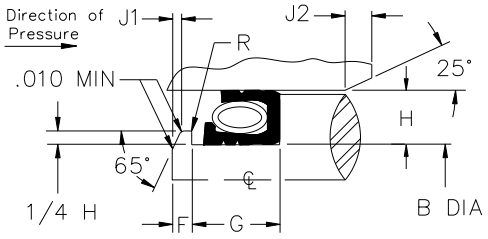


Figure 3
P-Series - ¼ H Gland Design

Gland Height	Gland Width	Step Radius	¼ H step Width	Chamfer length		Minimum Seal ID	Maximum Recommended Seal ID	Step Diameter
H	G	R	F	J1	J2	B	B	S1
0 = 1/16 (0.061/0.063)	0.098/0.103	0.002/0.010	0.034/0.044	0.015± 0.002	0.062± 0.005	0.312	1.875	0.343
4 = 3/32 (0.093/0.095)	0.144/0.154	0.002/0.010	0.055/0.065	0.020± 0.003	0.093± 0.006	0.438	2.875	0.484
5 = 1/8 (0.125/0.127)	0.183/0.193	0.002/0.010	0.078/0.088	0.025± 0.003	0.125± 0.008	0.750	3.750	0.813
6 = 3/16 (0.187/0.189)	0.263/0.273	0.002/0.010	0.120/0.130	0.030± 0.003	0.187± 0.010	1.125	5.625	1.219

CHART #3

3.2.2 Assembly Instructions

Install the P-series Bal Seal manually into the ¼ H step gland that has a 65°chamfer, as follows:

1. Insert one side of the Bal Seal into the top of the groove and push forward, as shown in Figure 4.
2. Press the Bal Seal firmly and evenly forward and down around the circumference in opposing directions until the seal snaps into the bottom of the groove. Once the Bal Seal is in the groove, use the sizer tool to re-shape the seal into the groove diameter. Leave tool in place for at least one hour, preferably for 24 hours.

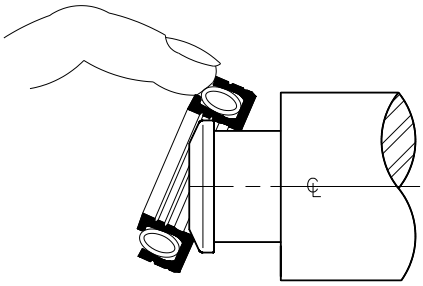


Figure 4
Manual Seal Assembly

See page 12 for more information on the sizer tool.

3.3 Various Bal Seal® Gland Designs (¼, ½ Step) (Tools Required)

The Bal Seal gland designs shown require tools for seal assembly. Locate information about assembly tools on pages 9 to 14. (All designs shown will cause permanent deformation to the seal)
Dimensions for various Bal Seals are shown in Figures 5, 6, 7, and in Charts #4 and #5.
These Bal Seals can withstand pressures to 3,000 psi (211 kg/cm^2), Figure 6 to 10,000 psi. (703kg/cm^2).

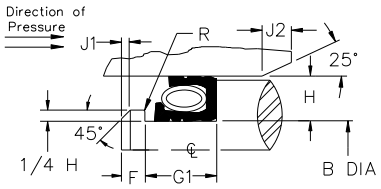


Figure 5 - P-Series Only

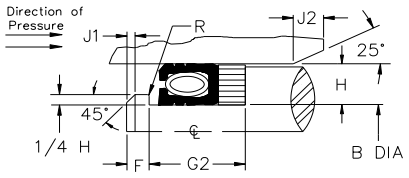


Figure 6 - P-Series Only

Back-up ring made from PTFE (For high performance polymers or metals, use split back-up ring.)

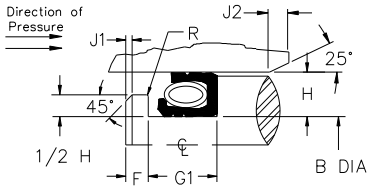


Figure 7

Bal Seal Dimensions							
Gland Height *	**Gland Width**	**Gland Width with Back-up Ring**	**Step Radius**	**Step Width**	**Step Width**	**Chamfer Length**	
H	**G1**	**G2**	**R**	**F**	**FF**	**J1**	**J2**
0 = 1/6 (0.061/0.063)	0.098/0.103	0.207/0.212	0.002/0.010	0.034/0.044	0.177/0.197	0.015± 0.003	0.062± 0.005
4 = 3/32 (0.093/0.095)	0.144/0.154	0.253/0.263	0.002/0.010	0.055/0.065	0.240/0.260	0.020± 0.003	0.093± 0.006
5 = 1/8 (0.125/0.127)	0.183/0.193	0.292/0.302	0.002/0.010	0.078/0.088	0.365/0.385	0.025± 0.003	0.125± 0.008
6 = 3/16 (0.187/0.189)	0.263/0.273	0.418/0.428	0.002/0.010	0.120/0.130	0.490/0.510	0.030± 0.003	0.187± 0.010

* Not recommended for larger cross-sections

CHART #4

CHART #5

Minimum Bal Seal ID based on cross-section and step				
Seal Cross-Section	**Minimum Seal ID ¼ H**	**Maximum Seal ID ¼ H**	**Minimum Seal ID ½ H**	**Maximum Seal ID ½ H**
W	**B**	**B**	**B**	**B**
0 = 1/16 (0.062)	0.219	1.875	0.312	1.875
4 = 3/32 (0.094)	0.312	2.875	0.375	2.875
5 = 1/8 (0.125)	0.750	3.750	1.000	3.750
6 = 3/16 (0.187)	1.000	5.625	1.250	5.625

3.4 High-Pressure Designs - P-Series

High-pressure P-series Bal Seals® withstand pressures to 10,000 psi. Various high-pressure seal designs are shown in Figure 9.

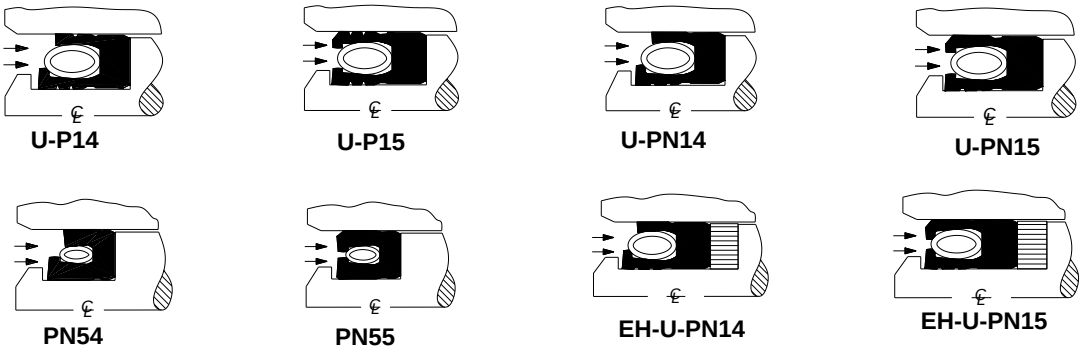


Figure 9 - P-Series High-Pressure Designs

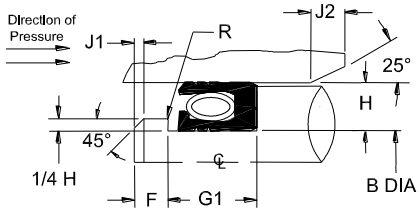


Figure 10 - High-Pressure Gland

Figure 10 shows a standard P-series high-pressure seal gland (¼ step).

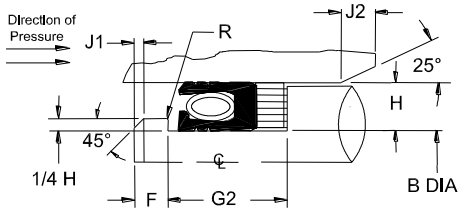


Figure 11 - High-Pressure Gland with Back-up Ring

Figures 11 shows a standard P-series high-pressure seal gland (¼ step) with a PTFE filled backup ring.

Gland dimensions for step-mounted high pressure BAL™ Seals									
Gland height	**Gland width**	**Gland Width**	**Step Radius**	**Step Width**	**Step Width**	**Chamfer Length**		**Min Seal ID ¼ H**	**Max Seal ID ¼ H**
H	**G1**	**G2**	**R**	**F**	**FF**	**J1**	**J2**	**B**	**B**
0 = 1/6 (0.061/063)	0.120/0.125	0.234/0.239	0.002/0.010	0.034/0.044	0.177/0.197	0.015 ± 0.003	0.062 ± 0.005	0.437	1.875
4 = 3/32 (0.093/0.95)	0.183/0.193	0.292/0.302	0.002/0.010	0.055/0.065	0.240/0.260	0.020 ±. 0003	0.093 ± 0.006	0.562	2.875
5 = 1/8 (0.125/0.125)	0.263/0.273	0.372/0.382	0.002/0.010	0.078/0.088	0.365/0.385	0.025 ± 0.003	0.125 ± 0.008	1.000	3.750
6 = 3/16 (0.187/0.189)	0.351/0.366	0.506/0.521	0.002/0.010	0.120/0.130	0.490/0.510	0.030 ± 0.003	0.187 ± 0.010	1.875	5.625

CHART #6 Gland Dimensions for Step-Mounted High-Pressure Bal Seals

4.0 SEAL INSTALLATION TOOLS

4.1 Availability of Assembly Tools

We do **NOT** make assembly tools for step piston-mounted seals.

Information to make assembly tools is provided in this document. However, Bal Seal Engineering accepts no responsibility for the performance of these tools; this information is provided as a service.

4.2 Assembly Tools – Description and Dimensions

Installation of a Bal Seal® into a stepped piston groove requires the following equipment: a collet, an adapter, and a sizing tool. Refer to Figure 12

The collet tool pushes and stretches the Bal Seal along the adapter tool, stretching the seal onto the piston shaft, and forward into the groove. The sizing tool pushes the deformed Bal Seal down into the groove, and compacts it to its initial size.

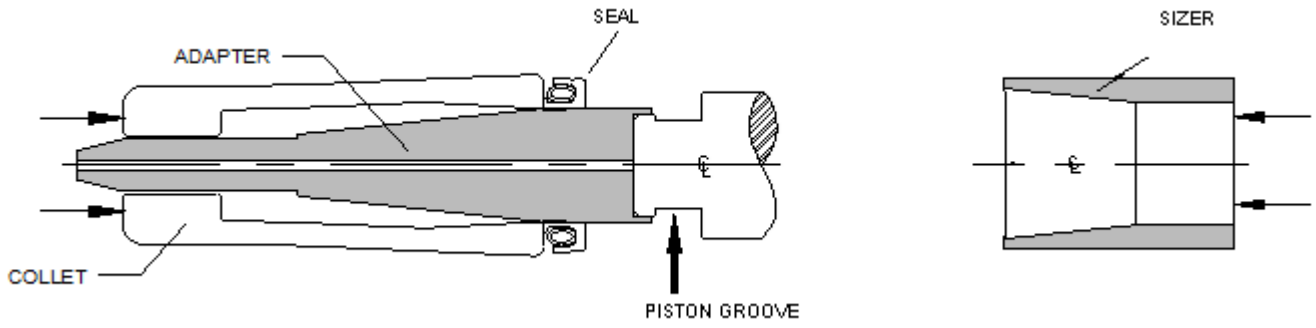


Figure 12: Assembly Tools

4.2.1 Adapter

The adapter tool eases assembly of the Bal Seal® into the piston groove. The seal stretches gradually and evenly over the adapter tool until it drops into the groove on the piston.

The adapter tool should be smooth and free from scratches or marks, which could damage the seal during installation. In addition, cutter tool grooves from the machining process can damage the seal if the finish is too coarse; there should be no sharp edges or rough surfaces.

The end of the adapter that fits over the piston step should be as thin as possible to minimize stretching the seal. Typical construction materials for the adaptor tool are Delrin®, nylon, and ultra-high-molecular-weight polyethylene.

Figure 13 and Charts #7 and #8 provide detailed data to construct an adapter.

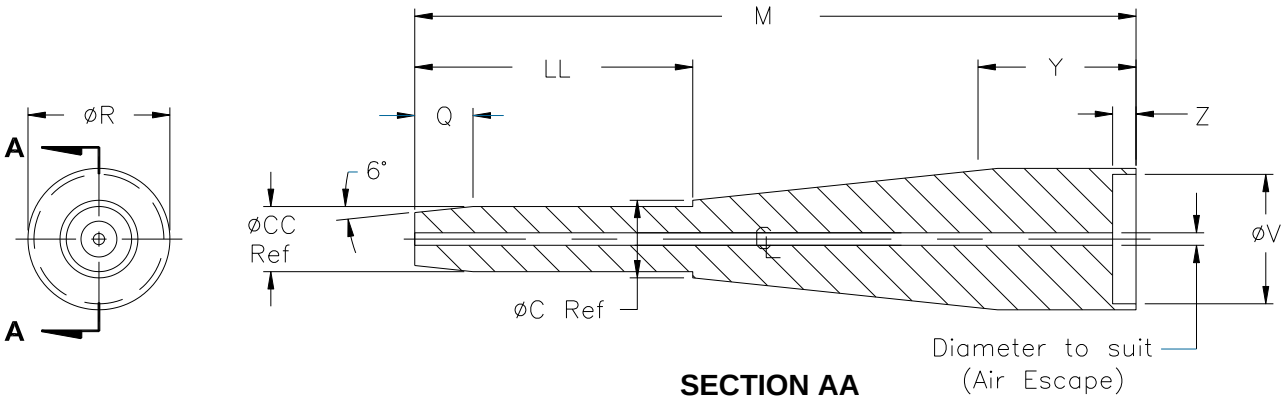


Figure 13
Adapter Tool

Diameters	C	CC	R	V
Tolerances	+0.003 -0.003	REF	+0.002 -0.002	Or Slip Fit With Shaft

Adapter Formulae	
C Diameter	Seal ID – 2 X Cross Section
V Diameter	Slip Fit Diameter
R Diameter	V Diameter + T
CC Diameter	Seal ID – 3 X Cross Section
Y Length	4 X Cross Section
Q Length	5 X Cross Section
Z Length	"C" Bore Depth To Suit Piston Step Length (1)
LL Length	30% Of M Dimension

CHART #7

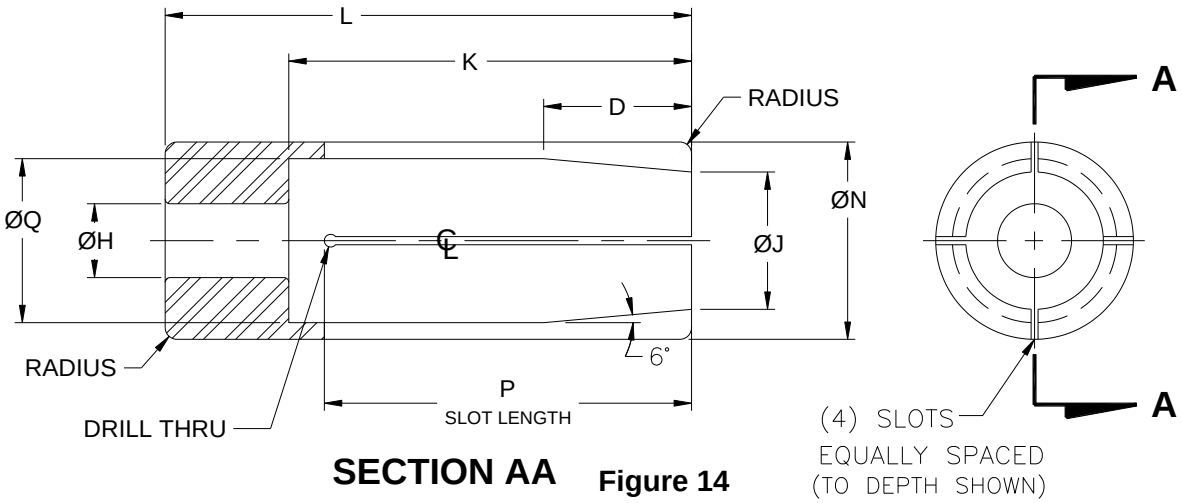
Constant Adapter Dimensions			
Series Code	Cross Section	T	M
101	0.031	0.016	1.620
100	0.063	0.018	2.292
104	0.094	0.020	2.969
105	0.125	0.022	3.765
106	0.188	0.024	5.105
107	0.250	0.026	6.692

CHART #8

4.2.2 Collet

The collet tool pushes the Bal Seal® over the adapter until the seal drops into the groove. Typical collet tool materials are Delrin®, nylon, and ultra-high-molecular-weight polyethylene.

Figure 13 and Charts #9 and #10 provide detailed data to construct the collet.



SECTION AA

Figure 14
Collet Tool

CHART #9

Dia.	Formula	Tolerance
Q	Seal OD	+0.004 / -0.004
J	Seal ID	+0.004 / -0.004
H	Seal ID – YY	+0.004 / -0.004
N	Q + NN	+0.004 / -0.004

CHART #10

Constant Collet Dimensions and Factors							
Series code	Cross section	D REF	K	L	S	NN	YY
101	0.031	0.297	1.144	1.390	1.080	0.062	0.037
100	0.063	0.595	1.614	1.860	1.490	0.125	0.083
104	0.094	0.892	2.088	2.340	1.900	0.187	0.272
105	0.125	1.189	2.646	2.890	2.270	0.250	0.365
106	0.188	1.784	3.584	3.830	3.000	0.375	0.546
107	0.250	2.376	4.694	4.940	3.940	0.500	0.735

4.2.3 Sizer

The sizer tool squeezes the seal into the groove after installation. The taper and inside diameter of the sizing tool must be smooth and free from scratches, marks, or sharp edges, which could damage the seal during assembly, creating leakage paths.

Interference must be present between the seal OD and the ID of the sizing tool at assembly.

PTFE is a suitable material because it is soft and flexible, and can force the seal towards the bottom of the groove better than other materials.

Figure 15 and Chart #11 provides detailed data to construct the sizer.

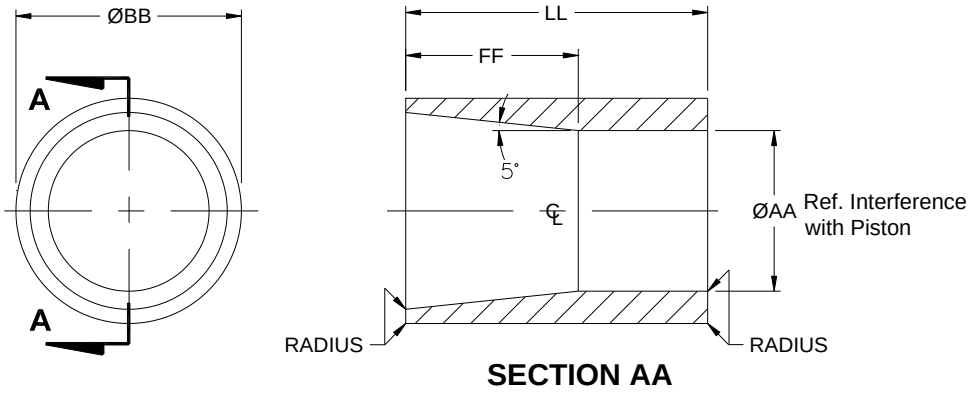


Figure 15
Sizer Tool

Diameter tolerances	ØBB	ØAA
	+0.010 -0.005	Interference with piston

Sizer And Constant Dimensions				
Series Code	**Cross Section**	**LL**	**FF**	**ØBB Tolerance**
101	0.031	0.750	0.180	AA +0.060
100	0.063	1.050	0.360	AA +0.142
104	0.094	1.250	0.540	AA +0.243
105	0.125	1.750	0.720	AA +0.363
106	0.188	1.880	1.070	AA +0.605
107	0.250	2.000	1.430	AA +0.885

CHART #11

5.0 SEAL INSTALLATION INSTRUCTIONS

5.1 Cautions

A stepped gland makes seal assembly easier because it stretches the seal less than a full gland. It is more difficult to return a seal to its original diameter the more it is stretched. The seal will be permanently deformed for all stepped glands.

A large ratio of the Bal Seal® inside diameter to the seal cross-section will ease this process. In addition, a thin film of wet lubricant facilitates Bal Seal assembly by lowering the friction between the seal and the mating parts.

5.2 Bal Seal Installation and Sizing

Install Bal Seals in two steps as follows:

Step 1 - Figure 16: Use the collet to slide the Bal Seal over the adapter until the seal drops into the piston groove. A thin film of wet lubricant facilitates assembly.

Step 2 - Figure 17: Work the seal into the bottom of the seal groove using the sizing tool.

Assembly requires interference between the piston and sizing tool, so substantial force may be required. Larger sizes may require a worm screw clamp around the outside of the sizing tool to force the seal into the bottom of the groove.

Leave the sizing tool in place for a minimum of one hour, preferably 24 hrs. The seal should be seated tightly in the bottom of the groove. Tim

Figure 16: Step 1

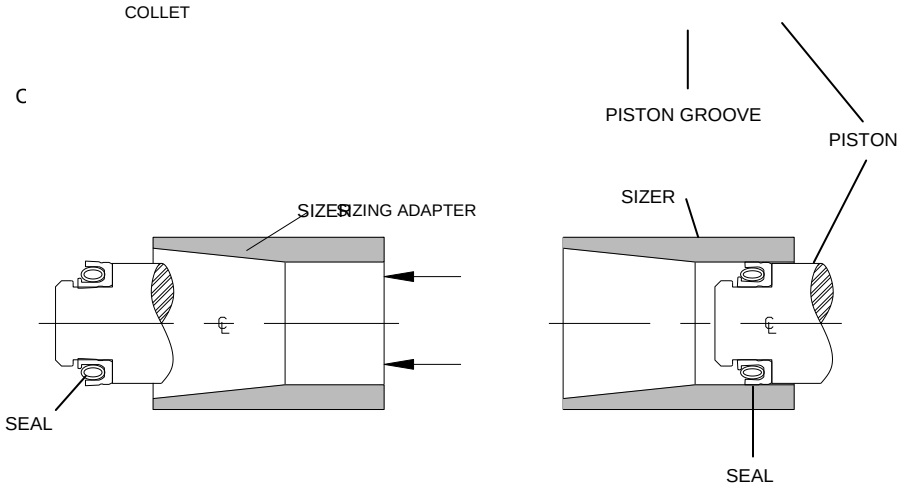


Figure 17: Step 2