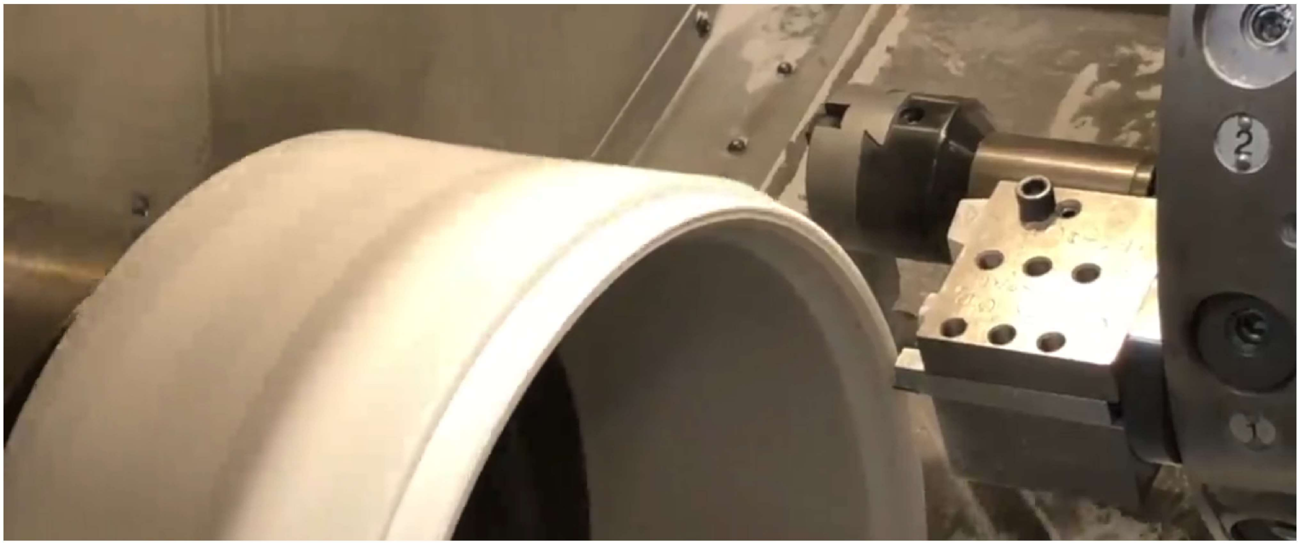
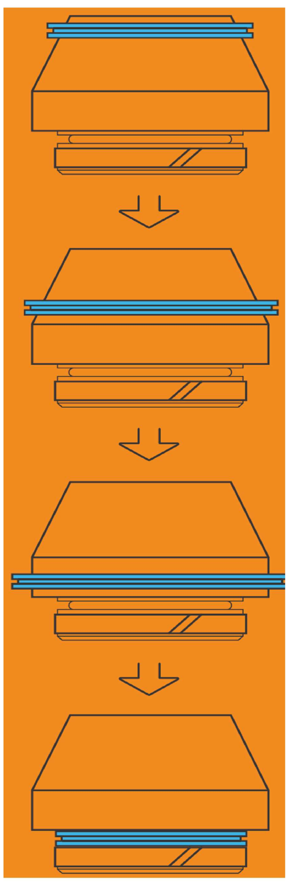
T-LON® Seal Installation & Hardware Expertise

PTFE Sealing Expertise





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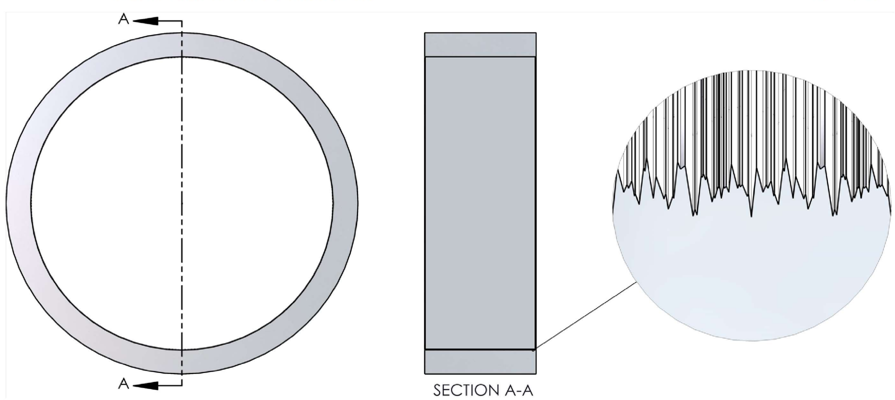

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I. Hardware Surface Finish Requirements

A. **Surface finish is critical for avoiding:**

1. Excessive seal wear
    a. Too Rough - Abrasive wear to seal
    b. Too Smooth - Adhesion wear to seal in dynamic applications
2. Hardware damage /surface scratching (See Figure 1)
3. Leakage
4. System Failure

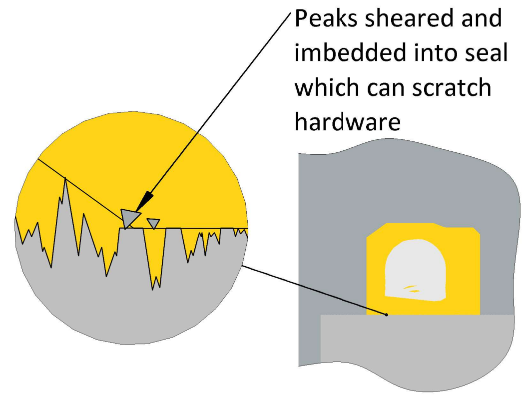

Figure 1: PTFE seal plowing rough peaks

B. Types of T-lon seals require different surface finishes

1. PTFE Static seals (Seal is not in contact with moving parts):
    a. Control of Ra is critical (See Table 1)
2. PTFE Dynamic seals (Seal is in contact with moving parts):
    a. Control of Ra plus Surface Roughness (Rz, Rt, Mr) is critical (See Table 1 and Figure 2 on the next page)
    b. Proper Selection of the Seal Compound: Seal compounds typically have fillers to improve friction and wear properties for dynamic applications. The fillers can be abrasive or non-abrasive which can cause premature failure for a specified surface finish. If the manufactured surface finish is rough, an abrasive filler may polish the surface to an acceptable working condition, but if the manufactured surface finish is too smooth, an abrasive filler may polish the surface even more causing seal adhesion and excessive seal wear.
    c. Reciprocating Sealing Surface Finish Exceptions: In dry running applications, extending seal life may be the primary focus. In this case, a rougher finish may be beneficial while sacrificing initial leakage control. As the seal slides over a rougher surface finish, seal material is imbedded into the mating surface until a steady state is reached. At this point, seal wear rate and friction are optimized.
    d. Rotary Sealing Surface Finish Additional Notes: Removing the shaft helical machining marks, "lead angle", is critical for avoiding higher rates of leakage and seal wear. The surface hardness and seal compound selection are also major factors in the success of rotary sealing. Seals are known to overpolish and potentially groove the mating components (see section II. Component Surface Hardness).
3. Elastomer seals (e.g. O-rings, Square Loaders, T-loaders for 4pc Piston Seals):
    a. Control of Ra is critical (See Table 2 on next page)

Table 1: Surface Finish Recommendations for Optimal PTFE Sealing Performance

Media	Rotary Application e.g. pumps, hydraulic motors, transmissions, mixers, blenders		Reciprocating Application e.g. piston cylinders (i.e. rod/piston seals), pilot valves		Static Applications e.g. valve seats, hydraulic and pneumatic fittings, face seals	
- Cryogenic Applications - Low Molecular Weight Gases (e.g. H, He, N, O)	R_t = 1.00 µm R_z = 0.63 µm R_a = 0.10 µm M_r = 50-90% at C=.25R_z	R_t = 39 µin R_z = 25 µin R_a = 4 µin M_r = 50-90% at C=.25R_z	R_t = 2.50 µm R_z = 1.60 µm R_a = 0.20 µm M_r = 50-90% at C=.25R_z	R_t = 98 µin R_z = 63 µin R_a = 8 µin M_r = 50-90% at C=.25R_z	R_a = .2 µm	R_a = 8 µin
- Low Viscosity Fluids (e.g. water, alcohols, natural gas, air)	R_t = 2.50 µm R_z = 1.60 µm R_a = 0.20 µm M_r = 50-90% at C=.25R_z	R_t = 100 µin R_z = 63 µin R_a = 8 µin M_r = 50-90% at C=.25R_z	R_t = 3.50 µm R_z = 2.20 µm R_a = 0.30 µm M_r = 50-90% at C=.25R_z	R_t = 138 µin R_z = 87 µin R_a = 12 µin M_r = 50-90% at C=.25R_z	R_a = .4 µm	R_a = 16 µin
All other media	R_t = 2.50 µm R_z = 1.60 µm R_a = 0.20 µm M_r = 50-90% at C=.25R_z	R_t = 100 µin R_z = 63 µin R_a = 8 µin M_r = 50-90% at C=.25R_z	R_t = 4.00 µm R_z = 2.50 µm R_a = 0.40 µm M_r = 50-90% at C=.25R_z	R_t = 157 µin R_z = 98 µin R_a = 16 µin M_r = 50-90% at C=.25R_z	R_a = .6 µm	R_a = 24 µin

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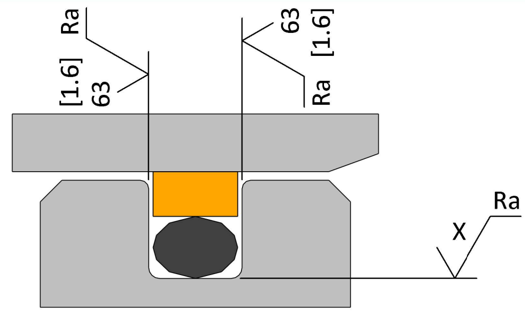
Table 2: Surface Finish for Elastomer Sealing

Media	**"X" - Loader Applications** e.g. Using an elastomer in conjunction with a dynamic sealing element – Reference schematic to the right	
- Vacuum - Gases	R_a = .4 μm	R_a = 16 μin
- Liquids	R_a = .8 μm	R_a = 32 μin



C. Surface finish definitions and guidelines:

1. See Table 3 for surface finish definitions and Table 4 for measuring the appropriate length of the hardware
2. Figure 2 shows why the control of Material Ratio is critical and why it is important to specify controls other than Ra. Even though the Ra may be the same, the material ratio can be drastically different with different surface textures.

Table 3: Surface Finish Definitions for Effective Sealing

Ra (Arithmetic Average Roughness) Ra is the arithmetic average height of peak heights and valleys from the mean line, measured within the sampling length. **Rz (Mean Roughness Height)** The arithmetic mean value of the single roughness depths of consecutive sampling lengths. Z is the sum of the height of the highest peaks and the lowest valley depth within a sampling length. **Rt (Max. Roughness Height)** The distance from the highest peak to the deepest valley within the evaluation length. **Mr (Material Ratio, %)** The material ratio is determined by an intersecting line which separates the peaks from the roughness core profile. It is the ratio between the intersection lengths and the sampling length.	**λc (Cutoff)** Cutoff of a profile filter determines which wavelengths belong to roughness and which ones to waviness. **rl (Sampling Length)** Sampling length is the reference for roughness evaluation. Its length is equal to the cutoff wavelength. **Traversing Length** Overall length traveled by the stylus when acquiring the traced profile. It is the total of Pre-travel, evaluation length, and post travel. **L (Evaluation Length)** Part of the traversing length from where the values of the surface parameters are determined. In general, this is 5 times the sample length. See chart below to determine evaluation length.

Table 4: Determining Proper Evaluation Length

Profile				**Cutoff**		**Sample Length**		**Evaluation Length**	
R_Z (μm)	**R_a** (μm)	**R_Z** (μin)	**R_a** (μin)	**λc** (mm)	**λc** (in)	**lr** (mm)	**lr** (in)	**L** (mm)	**L** (in)
0.1 Max	0.02 Max	4 Max	1 Max	0.08	0.003	0.08	0.0031	0.4	0.016
Over 0.1 Up to 0.5	Over 0.02 Up to 0.1	Over 4 Up to 20	Over 1 Up to 4	0.25	0.01	0.25	0.0098	1.25	0.049
Over 0.5 Up to 10	Over 0.1 Up to 2	Over 20 Up to 394	Over 4 Up to 79	0.8	0.031	0.8	0.0315	4	0.157

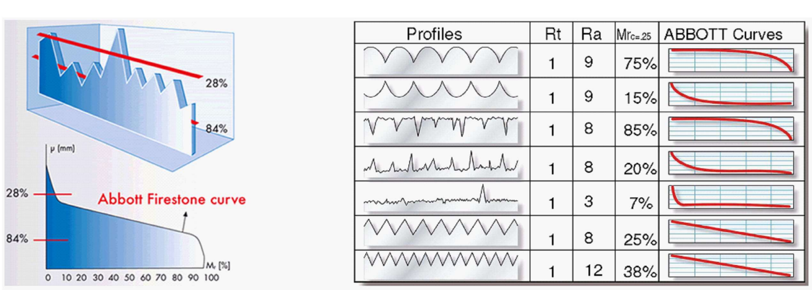
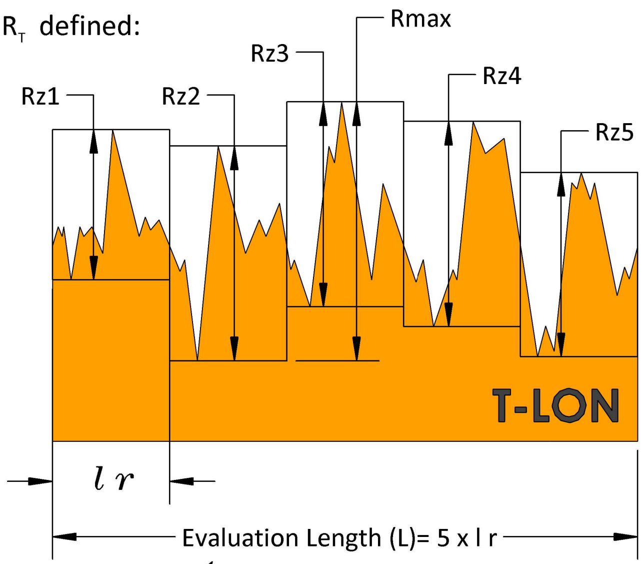


Figure 2: Material Ratio Created from Abbott-Firestone Curve

D. Surface finish definitions and guidelines continued:

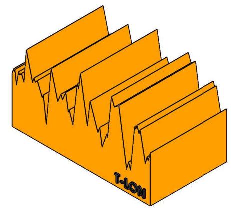
1. Calculating surface roughness and material ratio is performed as follows

R_Z and R_T defined:



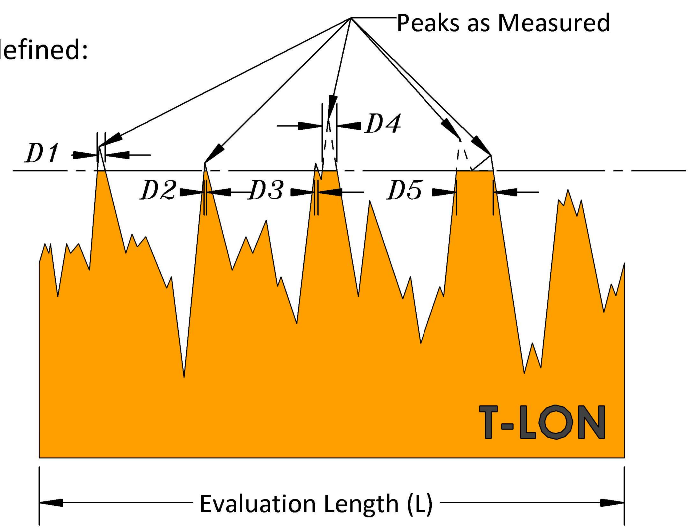
$$1)\ R_Z = \frac{1}{5}(R_{Z1}+R_{Z2}+R_{Z3}+R_{Z4}+R_{Z5})$$

$$2)\ R_T = R_{Max}$$



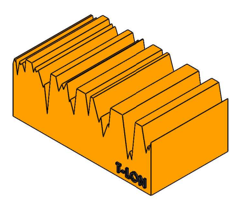
Surface Profile

M_R defined:

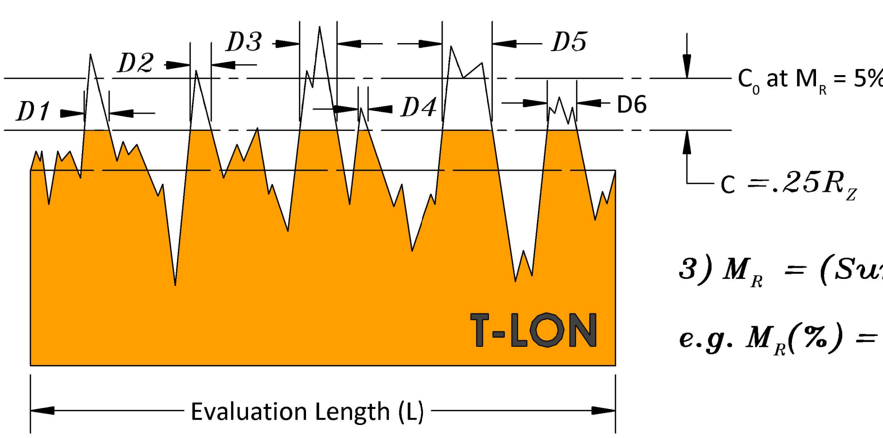


Reference line (C_0) at M_R = 5%

e.g. $\frac{1}{L}$(D1+D2+D3+D4+D5) = 5%



M_R *Calculated*



$$3)\ M_R = (Sum\ of\ D_n)/L,\ at\ C = .25R_Z$$

$$e.g.\ M_R(\%) = \frac{1}{L}(D1+D2+D3+D4+D5+D6)$$

II. Hardware Surface Hardness

A. Surface hardness is critical for avoiding:

1. Seal adhesion to mating components (Increasing seal friction)
2. Poor seal life
3. Poor component life
4. System Failure

B. Types of T-lon seals require different surface hardness

1. Static seals (Seal is in stationary gland/Not in contact w/ moving parts):
    a. Surface hardness not critical
2. Dynamic seals (Seal is in contact with moving parts):
    a. Dependent on seal material (e.g. T-lon 03) and sealing media (e.g. hydraulic oil). See TLon's Material Specification Tables for recommendations of seal compounds and mating surface hardness.
    b. In general, > 50 HRc. Harder surfaces require special attention to surface finish as the seal is less capable of polishing a harder surface. As the surface hardness increases, seal wear rate and friction decreases.
    c. In dry running applications, seal material will embed into the surface to improve performance, but with soft mating surfaces, the material will shed away as the mating surface is polished, and seal adhesion wear will result.
    d. Soft mating surfaces must use seal compounds with fillers that will not damage the hardware, but typically, this yields shorter seal life.
    e. In rotary sealing, some compounds are more likely to groove the dynamic mating component than others and a balance between the seal compound and the mating surface needs consideration so that the seal remains the wearable/replaceable item.
    f. Plasma spray coating, HVOF, ion nitriding, and gas nitriding are proven hardening treatments for successful PTFE rotary sealing.

III. Processing Methods to Improve Surface Finish and Surface Hardness

A. Improving Surface Finish

a. Grinding - Through testing, grinding has proven to be the best method of machining (reducing leakage, friction, and heat generation). Especially for rotary sealing,plunge grinding is recommended because spiral grinding marks may cause helical pumping leading to leakage (make sure to avoid even ratios between the part and grinding wheel speed).
b. Honing – Popular process for thru bores post turning, boring, reaming, or grinding.
c. Super Finishing – Similar to honing except for OD surfaces (e.g. shaft).
d. Polishing – Used to maintain tight tolerances while improving the surface finish.
e. Electro-polishing - Another process used to improve surface finish, especially when plunge grinding is impractical.
f. Roller Burnishing – Typically used on surfaces <Rc40 on internal or external surfaces. Material cold flows to improve surface finish

B. Surface Coating or Plating

a. The information supplied in **Table 5** is intended only as a guide. Testing of the selected material in actual service conditions is recommended to determine the suitability of a plating or coating for a specific application.
b. Note that some coatings cause a rougher surface finish and will require a post-polish to bring the surface finish within specification.
c. Many stainless steels provide good chemical compatibility but have limitations on available hardness. These materials are often plated to provide the added degree of hardness.

Table 5: Mating Component Finishing Processes

Coating or plating type		Hardness Rockwell C	Suggested thickness	Corrosion resistance	Abrasiveness to seal	Comments
Chrome plating	Hard chrome	65	0.0008/0.0050 in 0.020/0.127 mm	Fair to Good	High	Wear-resistant for light-duty. Not recommended for fast-rotary or corrosive applications.
	Thin dense chrome	70	0.0002/0.0006 in 0.005/0.015 mm	Excellent	Low	Higher wear resistance and lower friction than conventional chrome in light to moderate speeds.
Electroless nickel plating	Nickel as deposited	48-52	0.0010 in min. 0.0254 mm min.	Excellent	Low	Excellent for corrosive applications in light to moderate speeds and pressures.
	Nickel fully hardened	58-70	0.0010 in min. 0.0254 mm min.	Good	High	Harder but more abrasive than as-deposited nickel. Not recommended for high- speed rotary applications.
Plasma spray coating	Chromium oxide	71	0.0050/0.0300 in 0.127/0.762 mm	Excellent	Low	Recommended when wear life is the primary concern. Not recommended for high-shock loads.
	Aluminium oxide	60-69	0.0050/0.0300 in 0.127/0.762 mm	Excellent	Low	Lower-cost, less wear-resistant but greater ductility than chromium-oxide coatings.
HVOF	Tungsten Carbide	67-74	0.0050/0.0300 in 0.127/0.762 mm	Excellent	Low	High wear- resistance, with higher bonding strength. For high-speed and pressure combinations.
Anodizing	Hard anodized aluminum	Over 70	0.0005/0.0045 in 0.013/0.114 mm	Excellent	Low (Post-polish required)	Excellent bore material in piston-seal applications as a low-friction mating surface.
Thermal spray	Triballoy 400 & 800	55	0.0010/0.0200 in 0.025/0.508 mm	Excellent	High	Hard to get better than a 14 Ra so not recommended for most dynamic seal applications.
Gas Nitriding		Up to 70	0.0030/0.0100 in 0.076/0.254 mm	Excellent	Moderate (Post-polish required)	Wear resistant, low friction and resists corrosion. Thickness of coating can be an issue related to useful wear- life.
Ion Nitriding		Up to 70	0.0020/0.0040 in 0.051/0.102 mm	Excellent	Moderate (Post-polish required)	Superior to gas nitriding with less limitations for allowable metals.

IV. Seal Installation Methods

A. General Information

1. Hardware and installation tools should be free of nicks, burrs, scratches, or any sharp edges.
2. Lead-in chamfers on the hardware are recommended for installation to prevent seal damage and squeeze the seal cross-section into the gland.
3. To ease assembly, typical methods include heating the seals between 200-300°F [100-150°C] in air, water, or oil, and/or adding lubrication.
4. To prevent eccentric seal loading and over-compression, use wear rings to keep piston/shaft concentric to the housing.
5. If lead-in's are not present on a shaft or piston, stretch cones should be used (see Figure 3 & 4). Likewise, if lead-in's are not present in a bore or housing, tapered resizing sleeves should be used (see Figure 5).

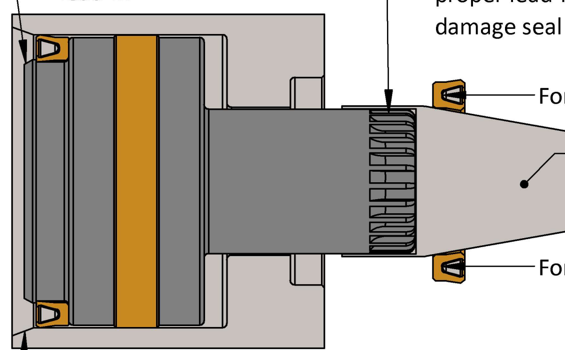


Figure 3: Hardware and Seal Installation Schematic

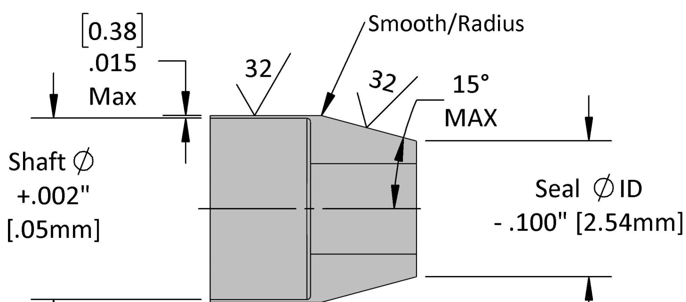


Figure 4: Typical Stretch Cone Design (Typically made from PA, POM, UHMW, PTFE)

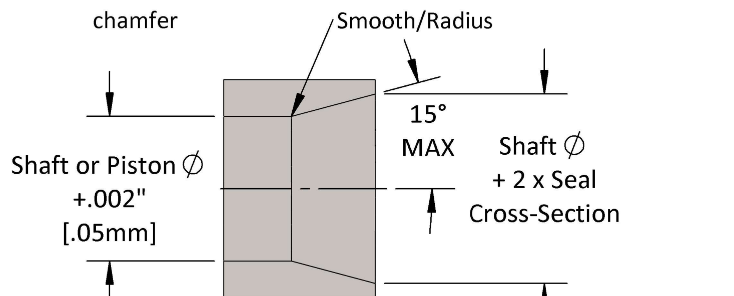


Figure 5: Typical Resizing Sleeve Design (Typically made from PA, POM, UHMW, PTFE)

B. Installing TLon Spring Energized Seals or U-cup Geometry Seals

1. If possible, avoid contacting the seal lips and apply force to the metal spring, energizer, or base of u-cup pocket, as shown in Figure 3, to install the seal into the gland. Otherwise, turn the seal around and apply force on the backside of the seal.
2. Piston and Shaft designs with open glands - Refer to Figure 3. Place a stretch cone onto the shaft or piston. Place the seal onto the stretch cone. Quickly apply uniform force to slide seal into the shaft or piston gland.
3. Piston designs with closed glands - Avoid this configuration for small diameter seals where the ID will stretch more than 10%. Extreme care must be taken while using a stretch cone and resizing sleeve to force the seal into the gland (see Figures 6-10 for a step by step process).
4. Shaft designs with closed glands - Avoid this configuration for small diameter seals where the seal ID is less than 25 times the cross-section. Extreme care must be taken while using a pusher tool to force and resize the seal into the gland (see Figures 11 & 12 for a step by step process).

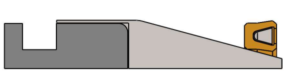


Figure 6: Place stretch cone and SES onto piston

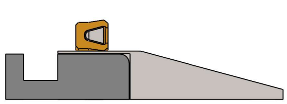


Figure 7: Applying force to the SES, slide it over the stretch cone

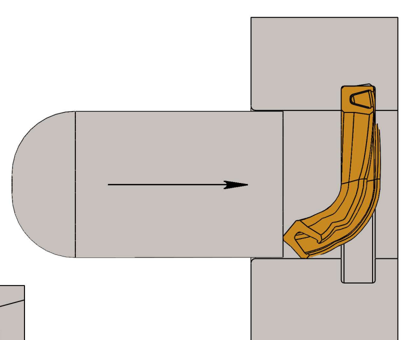


Figure 11: Deform Seal and Apply Force with Pusher Tool Blunt End

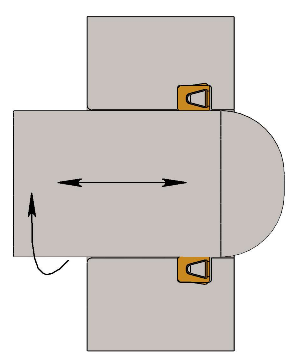


Figure 12: Resize Seal with the Pusher Tool Rounded End

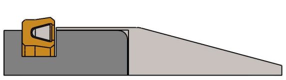


Figure 8: Push SES into seal groove

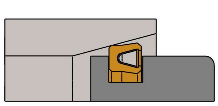


Figure 9: Remove stretch cone. Place resizing sleeve onto piston

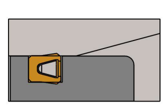


Figure 10: Force resizing sleeve over SES

C. Installing TLon Piston Seals (Review General Information in section IV.A.):

1. Piston designs with closed glands - Avoid this configuration for small diameter seals where the ID will stretch more than 10% for high-filled compounds (e.g. TLon 09, 15, and 22) and 15% for medium-filled compounds (e.g. TLon 03, 21, and 31). If more stretch is needed, consult TLon Engineering or consider a split groove design.
   a. **Pusher Tool Method:** Common installation method for ≤4" diameter piston seals. While using a pusher tool (Figure 13), stretch cone (Figure 4), and resizing sleeve (Figure 5), force the PTFE seal into the gland (see Figures 14-19 for a step by step process installing a 2pc Piston seal consisting of an o-ring and PTFE seal). Consult TLon for pricing.

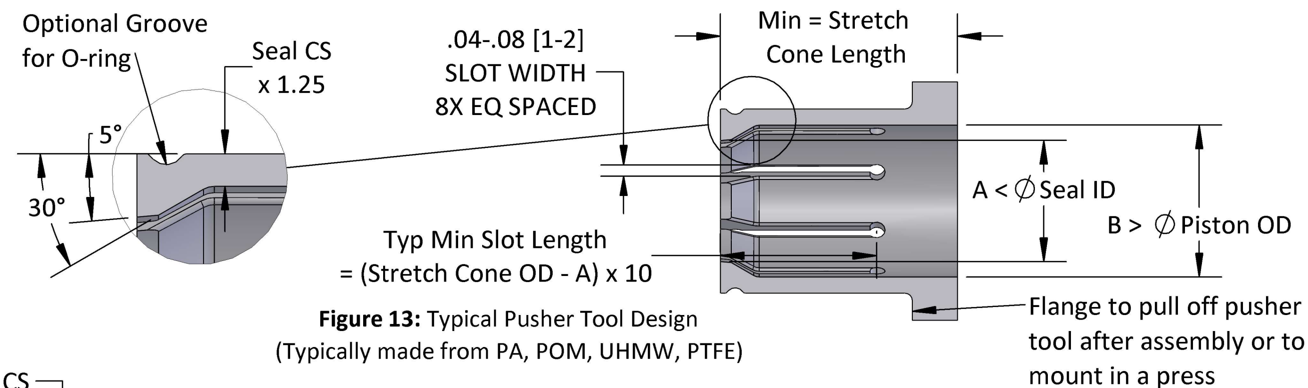


Figure 13: Typical Pusher Tool Design
(Typically made from PA, POM, UHMW, PTFE)

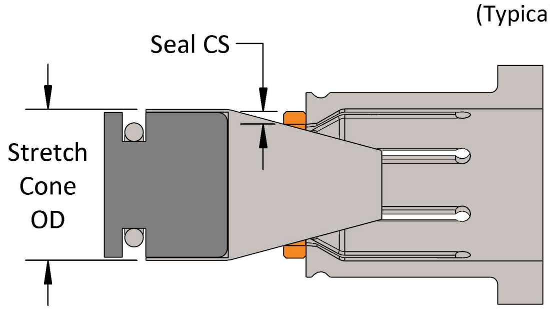


Figure 14: Install o-ring into the seal groove. Place stretch cone onto piston. Place PTFE seal and pusher tool onto stretch cone

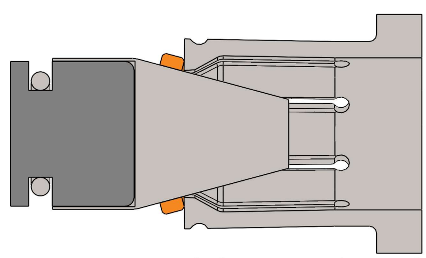


Figure 15: Apply force to pusher tool

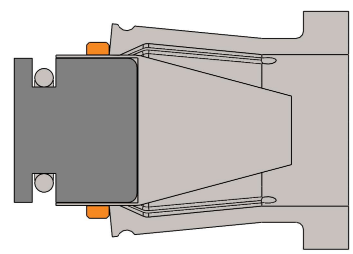


Figure 16: Continue pushing PTFE seal over stretch cone

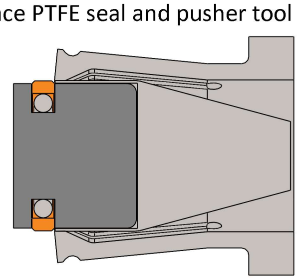


Figure 17: Continue pushing PTFE seal into seal groove

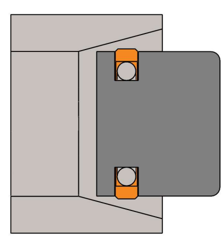


Figure 18: Remove pusher tool and stretch cone. Place resizing sleeve onto piston.

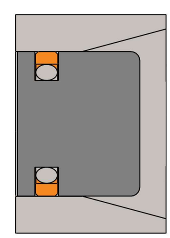


Figure 19: Force resizing sleeve over PTFE seal. Seal is ready for use

   b. **Manual Method:** Common installation method for >4" diameter piston seals. Using a thin plastic strip, stretch the PTFE seal, walking the plastic strip around the ring circumference and working the seal into the groove (see Figures 20 - 22).

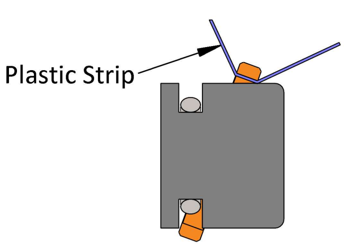


Figure 20: After o-ring is installed into seal groove, stretch the PTFE seal over the piston into the groove using a plastic strip.

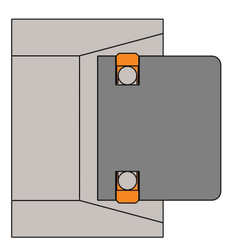


Figure 21: Remove plastic strip. Place resizing sleeve onto piston.

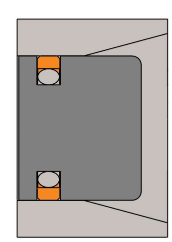


Figure 22: Force resizing sleeve over PTFE seal. Seal is ready for use

D. Installing TLon Rod Seals (Review General Information in section IV.A.):

1. Rod designs with closed glands - As a general rule, avoid this configuration for shaft diameters < 1.181" [30mm]. If the rod diameter divided by the seal cross-section exceeds 12, closed glands may be used. Otherwise, consider a split groove design.
   a. **Kidney-shape Method:** Deform the PTFE seal into the gland (see Figures 24-29 for a step by step process installing a 2pc rod seal consisting of an o-ring and PTFE seal) and use a rod resizing tool (Figure 23) to resize the seal for use. Alternatively, another option is to use your fingers and a mandrel with a 1.2 [30] x 10-15° taper lead-in to resize the seal. Consult TLon for installation tool pricing.

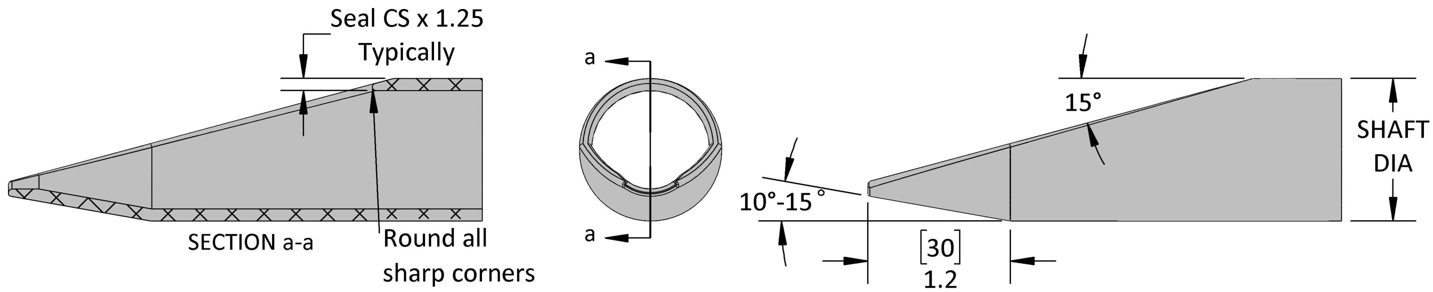


Figure 23: Typical Rod Resizing Tool Design
(Typically made from PA, POM, UHMW, PTFE)

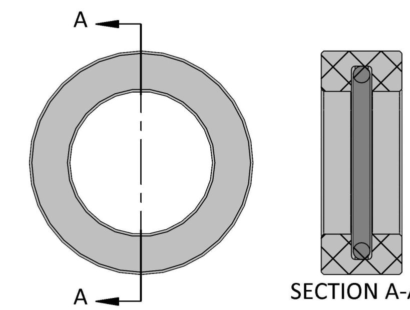


Figure 24: Install the o-ring into the seal groove

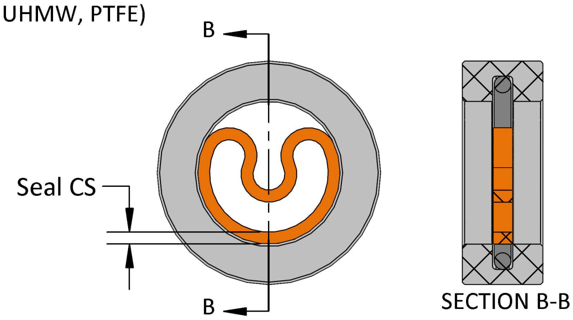


Figure 25: Deform the PTFE seal into a kidney bean shape so it will fit into the housing bore

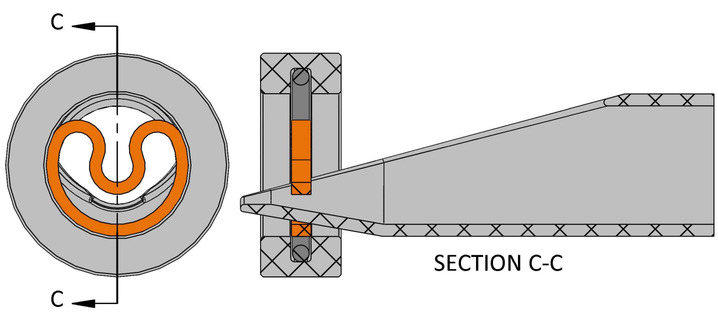


Figure 26: Insert the rod resizing tool through the seal ID. Alternatively, use your fingers to force seal into seal groove

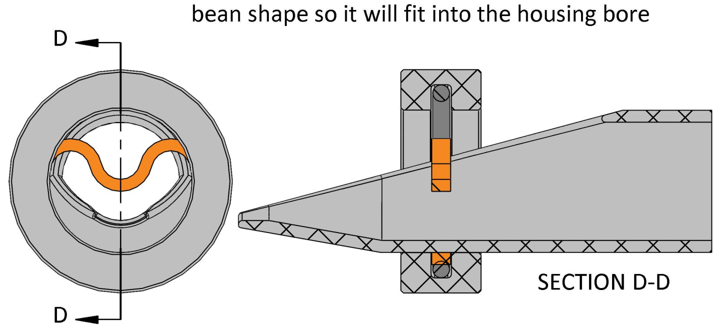


Figure 27: Continue pushing rod resizing tool so PTFE seal deforms into seal groove.

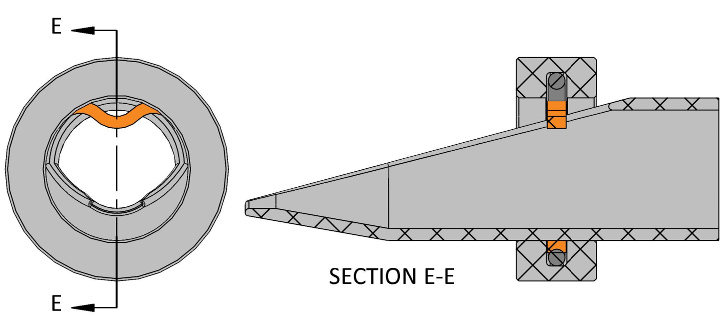


Figure 28: Continue pushing rod resizing tool. PTFE seal is almost resized into seal groove.

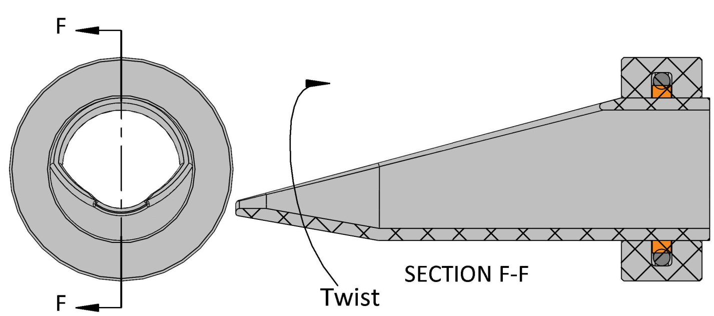


Figure 29: Start twisting and pushing rod resizing tool until PTFE seal is fully mounted onto mandrel. Remove tool, and the seal is ready for use.

b. **Pusher Tool Method:** Alternate rod seal installation method if the rod diameter divided by the seal cross-section exceeds 12. Using a rod pusher tool, reduction sleeve, and resizing mandrel, install the PTFE seal into a closed seal gland (see Figures 30 - 40).

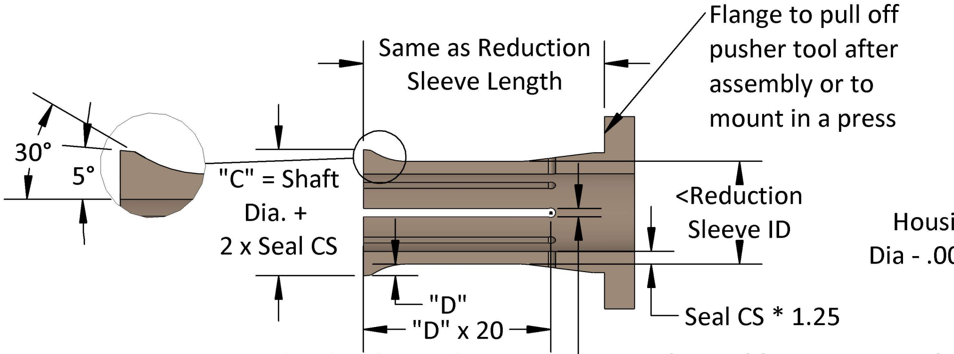


Figure 30: Typical Rod Pusher Tool Design (Typically made from PA, POM, UHMW, PTFE)

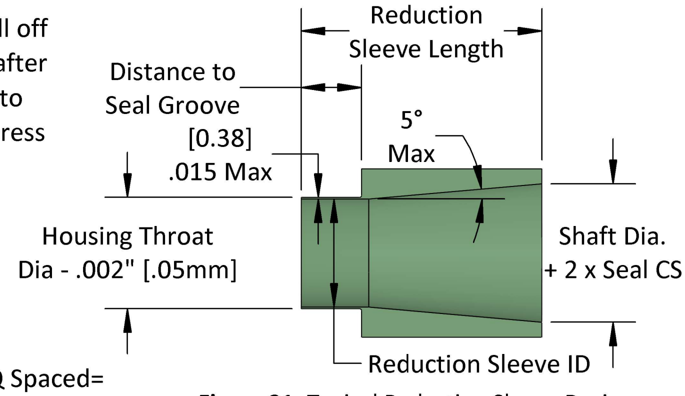


Figure 31: Typical Reduction Sleeve Design (Typically made from PA, POM, UHMW, PTFE)

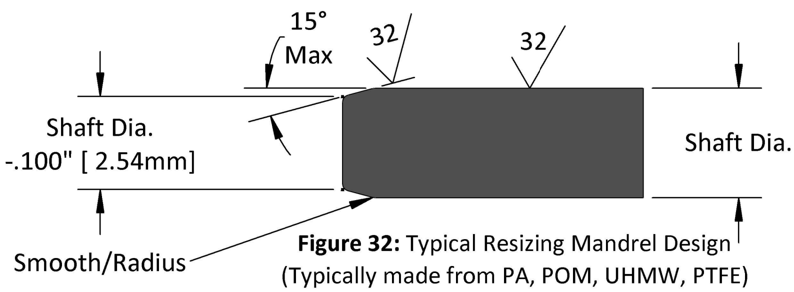


Figure 32: Typical Resizing Mandrel Design (Typically made from PA, POM, UHMW, PTFE)

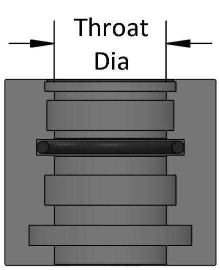


Figure 33: Insert o-ring into seal groove.

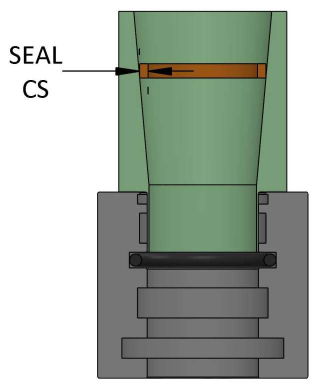


Figure 34: Insert reduction sleeve into housing. Then, insert PTFE seal into the reduction sleeve.

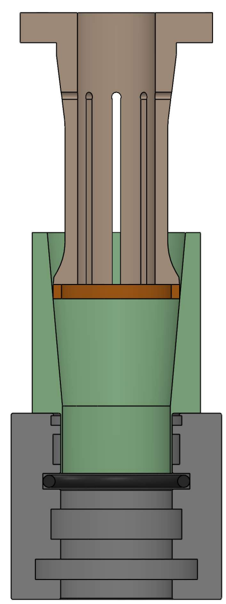


Figure 35: Place rod pusher tool on top of the PTFE seal.

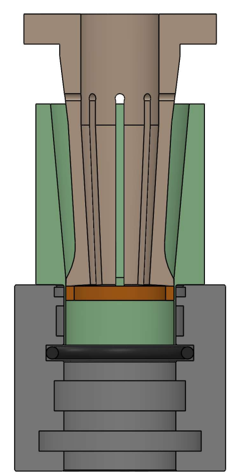


Figure 36: Apply force to rod pusher tool and force the PTFE seal into the reduction sleeve.

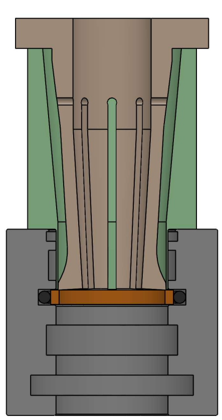


Figure 37: Continue to force the PTFE seal into the seal groove.

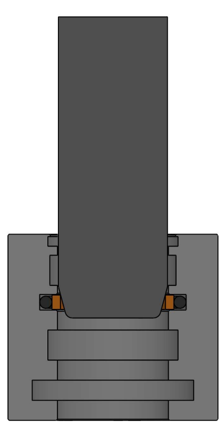


Figure 38: Remove reduction sleeve and pusher tool. Insert resizing mandrel.

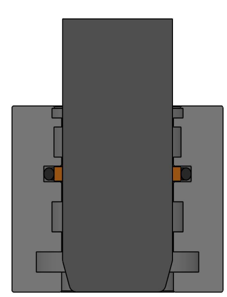


Figure 39: Force resizing mandrel through seal.

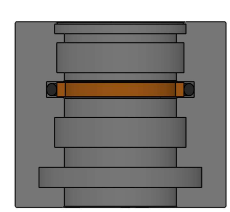


Figure 40: Remove resizing mandrel. Seal is resized and ready for use.