

Profile Matrix & Specifications QuickFind

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Introduction

This chapter will provide the design engineer, who is familiar with radial shaft seal design parameters, the information needed to select and control the optimum sealing profile. ESP has created an organized **Profile Selection Matrix** that is customer friendly and easy to understand. Although it helps to be rehearsed in how system sealing parameters can affect lip and O.D. styles (see **Design Chapter**, Parameters section) it is not required. To fully utilize this section a brief explanation is needed to provide instruction and explanation of its intended use.

The **Profile Selection Matrix** is designed in rows and columns based on lip and case type designations. When moving from left to right the lip type remains constant as the case options change. In a similar manner, moving up and down reveals different lip options. The “type” designation and description are at the beginning of each column and row.

These descriptions are intended to provide general usage information to aid in the selection process. For applications with limited profile choices the matrix has been reduced to single row format. If a profile option does not appear in the matrix please contact ESP Engineering.

The **Operations Table** was created to provide guidelines for the intended use of radial shaft seal profiles. This table can be used before and after profile selection. When using before, the type of lip style can be narrowed down by looking at the operational range and determining which profiles are designed to operate under these conditions. After a profile has been selected this table should be consulted to reaffirm proper selection. For parameters outside the ranges given for operation please contact ESP Engineering.

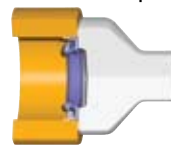
Hydrodynamic Aids can provide vital sealing assistance for a given lip style. This section provides a 2-D view of the air side angle with an aid style designation. For further explanation of how these aids are used in application refer to page 30B in the **Design Information** chapter. The use of a hydrodynamic aid is represented by placing an “H” in front of the radial shaft seal profile designation. If a “TC” profile utilizes a hydrodynamic aid the designation would be “HTC”. More specifically, the aid style will be attached to the end of the profile designation. For a “U5” style aid, in the above example, the complete profile designation would be “HTCU5”.



The **Design Specifications** section is organized to provide recommendations of shaft and bore and seal tolerances. These specifications conform to radial shaft seal industry standards and were created to provide consistency for the customer. Checking to make sure the system components meet these specifications will help regulate and control an optimal environment.

The last section is an **Installation Guide** showing proper and improper methods. Detailed models have been created to show common tool styles and mistakes. Like the specifications section, installation methods are important for optimal sealing performance.

Selecting the correct profile and regulating the design specifications are meaningless if the seal is cocked in the bore because of improper installation. Use this section as a guideline for installation method suggestions.

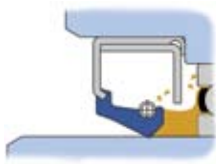


Profile Matrix

Installation direction if sealing grease or viscous fluid and exclusion of foreign material is of primary concern



Typical installation direction



General Applications

		Cast or steel housing where structural rigidity is required	Cast or steel housing	Cast or steel housing, suitable for applications where corrosion by sealed fluid could be a problem	Cast or steel housing, suitable for applications where corrosion by sealed fluid could be a problem, rubber "nose" improves O.D. sealability	Soft alloy or plastic housing, or as replacements if housing surface is damaged
	Case Type	A2	B2	B	BR	C
	Lip Type	Dual metal case, metal O.D.	Single metal case, metal O.D.	Single metal case with rubber on internal cavity, metal O.D.	Single metal case with rubber on internal cavity, metal O.D., with rubber nose	Rubber coated case
General standard pressure fluid sealing and severe grease sealing	S - Single spring loaded lip	SA2 	SB2 	SB 	SBR 	SC
General standard pressure fluid sealing and severe grease sealing with light duty exclusion of foreign materials	T - Single spring loaded lip with dust lip	TA2 	TB2 	TB 	TBR 	TC
General standard pressure grease and viscous fluid sealing	V - Single lip	VA2 	VB2 	VB 	VBR 	VC
General standard pressure grease and viscous fluid sealing with light duty exclusion of foreign materials	K - Single lip with dust lip	KA2 	KB2 	KB 	KBR 	KC
General standard pressure fluid sealing and severe grease sealing, inverted dust lip allowing for pre-lubrication of seal	X - Single spring loaded lip with inverted dust lip	XA2 	XB2 	XB 	XBR 	XC
General fluid sealing and severe grease sealing where separation of two fluids is required	D - Dual spring loaded lips	DA2 	DB2 	DB 	DBR 	DC
General standard pressure grease retention with heavy duty exclusion of mud and water	U - Triple sealing lips	UA2 	UB2 	UB 	UBR 	UC

Profile Matrix

General Applications

Soft alloy or plastic housing, suitable for applications where corrosion could be a problem	Soft alloy or plastic housing, ribs reduce installation forces	Steel or soft alloy housings, provides metal to metal fit and sealing ability of rubber, reducing springback	Steel or soft alloy housings, provides metal to metal fit and sealing ability of rubber, reducing springback and installation forces	Cast or steel housing, suitable for applications when metal to metal pressfit is desired but still want case protected from the elements	Cast or steel housing, shotgun case allows for easy installation / replacement and restricts installation depth. Additional case adds structural rigidity	Cast or steel housing, shotgun case allows for easy installation / replacement and restricts installation depth	Cast or steel housing, flange allows for easy installation / replacement and restricts installation depth. Additional can adds structural rigidity
CF	G	BC	BG	BC1	AP	BP	AD
Rubber coated case, rubber thickened	Rubber coated case with ribs added to O.D.	Single metal case, metal O.D., with half/half design	Single metal case, metal O.D., with half/half design and ribs added to O.D.	Single metal case, metal O.D., with rubber coated case	Dual metal case, metal O.D., with shotgun case design	Single metal case, metal O.D., with shotgun case design	Dual metal case, metal O.D., with midcrimp of external case to internal case
SCF	SG	SBC	SBG	SBC1	SAP	SBP	SAD
TCF	TG	TBC	TBG	TBC1	TAP	TBP	TAD
VCF	VG	VBC	VBG	VBC1	VAP	VBP	VAD
KCF	KG	KBC	KBG	KBC1	KAP	KBP	KAD
XCF	XG	XBC	XBG	XBC1	XAP	XBP	XAD
DCF	DG	DBC	DBG	DBC1	DAP	DBP	DAD
UCF	UG	UBC	UBG	UBC1	UAP	UBP	

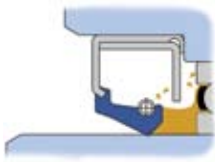


Profile Matrix



















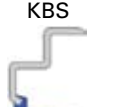




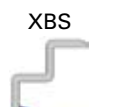




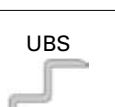
Installation direction if sealing grease or viscous fluid and exclusion of foreign material is of primary concern

















































Typical installation direction



General Applications

		Soft alloy or plastic housing, reverse channel case allows for easy installation/replacement and restricts installation depth	Cast or steel housing, reverse channel case allows for easy installation/replacement and restricts installation depth	Cast or steel housing, case design adds rigidity as well as allowing for installation from both sides	Cast or steel housing, case design is used to accommodate large clearances between shaft and bore	Cast or steel housing, straight channel case allows for easy installation/replacement and restricts installation depth
	Case Type	CJ	BJ	BH	BS	B2L
	Lip Type	Rubber coated case, with reverse channel case design	Single metal case, metal O.D., with reverse channel case design	Single metal case, metal O.D., with reverse channel case without flange	Single metal case, metal O.D., with stepped case design	Single metal case, metal O.D., with straight channel case design
General standard pressure fluid sealing and severe grease sealing	S - Single spring loaded lip	SCJ 	SBJ 	SBH 	SBS 	SB2L 
General standard pressure fluid sealing and severe grease sealing with light duty exclusion of foreign materials	T - Single spring loaded lip with dust lip	TCJ 	TBJ 	TBH 	TBS 	TB2L 
General standard pressure grease and viscous fluid sealing	V - Single lip	VCJ 	VBJ 	VBH 	VBS 	VB2L 
General standard pressure grease and viscous fluid sealing with light duty exclusion of foreign materials	K - Single lip with dust lip	KCJ 	KBJ 	KBH 	KBS 	KB2L 
General standard pressure fluid sealing and severe grease sealing. Inverted dust lip allowing for pre-lubrication of seal	X - Single spring loaded lip with inverted dust lip	XCJ 	XBJ 	XBH 	XBS 	XB2L 
General fluid sealing and severe grease sealing where separation of two fluids is required	D - Dual spring loaded lips	DCJ 	DBJ 		DBS 	
General standard pressure grease retention with heavy duty exclusion of mud and water	U - Triple sealing lips				UBS 	

Profile Matrix

General Applications		PTFE Coated Sealing Lip				Heavy Duty	
Soft alloy or plastic housing, straight channel case allows for easy installation/replacement and restricts installation depth	Soft alloy or plastic housing, straight channel case allows for easy installation/ replacement, with rubber coated flange for harsh environments	Cast or steel housing, PTFE molded to sealing lip, suitable for low lubrication applications	Cast or steel housing, PTFE molded to sealing lip, suitable for low lubrication applications where corrosion could be a problem	Soft alloy or plastic housing, PTFE molded to sealing lip, suitable for low lubrication applications	Soft alloy or plastic housing, PTFE molded to sealing lip, case allows for easy replacement and restricts installation depth	Cast or steel housing where structural rigidity is required, suitable for heavy duty applications	Cast or steel housing, suitable for heavy duty applications
CL	CL6	B2T	BT	CT	CLT	AM	BM
Rubber coated case with straight channel case design	Rubber coated case with straight channel case design, flange also rubber coated	Single metal case, metal O.D. with PTFE molded to sealing lip	Single metal case with rubber on internal cavity, metal O.D. with PTFE molded to sealing lip	Rubber coated case with PTFE molded to sealing lip	Rubber coated case with straight channel case design and PTFE molded to sealing lip	Dual metal case, metal O.D. with thick rubber on internal cavity	Single metal case, metal O.D. with thick rubber on internal cavity
SCL 	SCL6 	SB2T 	SBT 	SCT 	SCLT 	SAM 	SBM 
TCL 	TCL6 	TB2T 	TBT 	TCT 	TCLT 	TAM 	TBM 
VCL 	VCL6 	VB2T 	VBT 	VCT 	VCLT 	VAM 	VBM 
KCL 	KCL6 	KB2T 	KBT 	KCT 	KCLT 	KAM 	KBM 
XCL 	XCL6 	XB2T 	XBT 	XCT 	XCLT 	XAM 	XBM 
DCL 	DCL6 	DB2T 	DBT 	DCT 	DCLT 		

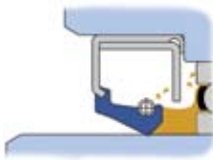


Profile Matrix

Installation direction if sealing grease or viscous fluid and exclusion of foreign material is of primary concern

























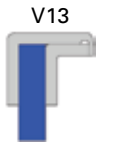




Typical installation direction



General Applications, O.D. Sealing





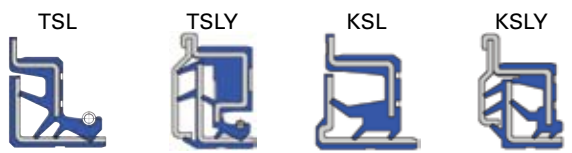
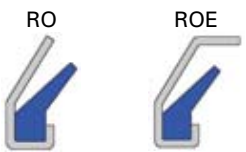
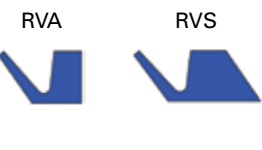
		Steel shaft where structural rigidity is required	Steel shaft	Steel shaft, suitable for applications where corrosion by sealed fluid could be a problem	Steel shaft, suitable for applications where corrosion by sealed fluid could be a problem, rubber "nose" improves O.D. sealability	Soft alloy or plastic shaft, or as replacements if shaft surface is damaged
	Case Type	A2 Dual metal case, metal O.D.	B2 Single metal case, metal O.D.	B Single metal case with rubber on internal cavity, metal O.D.	BR Single metal case with rubber on internal cavity, metal O.D., with rubber nose	C Rubber coated case
	Lip Type					
General standard pressure fluid sealing and severe grease sealing applications with sealing element contacting bore	OS - O.D. sealing single spring loaded lip	OSA2 	OSB2 	OSB 	OSBR 	OSC
General standard pressure fluid sealing and severe grease sealing with light duty exclusion of foreign materials and sealing element contacting bore	OT - O.D. sealing single spring loaded lip with dust lip	OTA2 	OTB2 	OTB 	OTBR 	OTC
General standard pressure grease and viscous fluid sealing with sealing element contacting bore	OV - O.D. sealing single lip	OVA2 	OVB2 	OVB 	OVBR 	OVC
General standard pressure grease and viscous fluid sealing with light duty exclusion of foreign materials and sealing element contacting bore	OK - O.D. sealing single lip with dust lip	OKA2 	OKB2 	OKB 	OKBR 	OKC
General standard pressure grease retention with heavy duty exclusion of mud and water and sealing element contacting bore	OU - O.D. triple sealing lips	OUA2 	OUB2 	OUB 	OUBR 	OUC

Profile Matrix

Design Characteristics	Style	Low Pressure Applications - 30 P.S.I., 2.1 Bar Max.
General low pressure fluid sealing applications (30 P.S.I., 2.1 Bar max.), seals with metal O.D. are designed for cast or steel housings, while rubber O.D. seals are for soft alloy or plastic housings	E	   
General low pressure fluid sealing with light duty exclusion of foreign materials (30 P.S.I., 2.1 Bar max.), seals with metal O.D. are designed for steel housings while, rubber O.D. seals are for soft alloy housings	E	   
Medium / High Pressure Applications		
General medium pressure fluid sealing applications (50-100 P.S.I., 3.4-6.9 Bar max.), seals are designed for soft alloy or steel housing	N	  50 psi max. 100 psi max.
General medium pressure fluid sealing with light duty exclusion of foreign materials (50-100 P.S.I., 3.4-6.9 Bar max.), seals are designed for soft alloy or steel housing	N	   50 psi max. 100 psi max. 100 psi max.
General high pressure fluid sealing applications (150 P.S.I., 10.3 Bar max.), seal is designed for soft alloy or steel housing, teflon ring prevents sealing lip from extruding	N	 150 psi max.
Dust Wipers for Reciprocating Applications		
General scraping / wiping applications such as hydraulic / pneumatic cylinder rods, seals with metal O.D. are design for cast or steel housings while rubber O.D. seals are for soft alloy or plastic housings	WP	    
General Grease Sealing Applications		
General standard pressure grease and viscous fluid sealing applications, seals are designed with dual metal case for structural rigidity and are intended to be used in cast iron or steel housings	V	    
General standard pressure grease retention with heavy duty exclusion of mud and water, type UB10 is a compact design for small housing to shaft clearances, type UA20 is for highly contaminated situations	U	  



Profile Matrix

Design Characteristics	Style	Linear Sealing Applications
General standard pressure applications where linear movement is prevalent, seals with metal O.D. are designed for cast or steel housings while rubber O.D. seals are for soft alloy or plastic housings	4	
Radial and Axial Face Sealing Applications		
General standard pressure applications, lip on outside face is designed to act as rotary axial face seal, seals with metal O.D. are design for cast or steel housings while rubber O.D. seals are for soft alloy housings	8-9	
High Eccentricity Applications - 0.060", 1.5 mm Max.		
General standard pressure fluid sealing and severe grease sealing applications where shaft eccentricity is excessive (0.060", 1.5 mm max.)	C	
General standard pressure fluid sealing and severe grease sealing with light duty exclusion of foreign materials, designed for applications where shaft eccentricity is excessive (0.060", 1.5 mm max)	C	
Extreme Sealing Applications		
General standard pressure fluid sealing and severe grease sealing, seals are designed for exclusion of foreign materials, usually used in harsh environments where seals will see large amounts of dirt and debris	SL	
Axial Face Seals		
General standard pressure axial face seal for heavy duty foreign material exclusion, metal case protects elastomer from being destroyed, see page 137F for sizes offered and design information	R	
General standard pressure axial face seal for heavy duty foreign material exclusion, see page 135F for sizes offered and design information	R	








































































Profile Matrix

Design Characteristics	Style	End Caps
Solid cap (no center hole) for sealing additional shaft location holes	E	
		Integral Wear Sleeves
Integral wear sleeves are for applications where shaft hardness does not meet design recommendations, also wear sleeves may be used in conjunction with a variety of seal designs to form a cartridge seal	LC	
		Bellow Seal
General nonpressure fluid and grease sealing applications where shaft or bore rotation is not present, bellow design allows for large shaft to bore movement	N	
		Valve Stem Seals
Valve stem seal	VS	
		Teflon Lip Seal
General standard pressure fluid and severe grease sealing applications, teflon lip is designed for high speed applications	T1	
		Fabric Auxiliary Lip
General standard pressure fluid and severe grease sealing applications, fabric lip is designed for when dust ingestion is a problem	K	

For oil seal designs not shown, please contact ESP Engineering for recommended designs to meet your application requirements.

Operations Table

Small Diameter Seals

Description	Standard Design	Other Designs with Similar Operating Conditions				
Single lip without spring for general standard pressure grease and viscous fluid sealing, install with lip facing to the air side for maximum dirt exclusion, not typically recommended for oil retention		VA2  VBH 	VBR  V13 	VC  V16 	VBC  V10 	VBJ  V15 
Dual lip without spring for general standard pressure grease and viscous fluid sealing, secondary lip is designed for light duty exclusion of foreign materials, not typically recommended for oil retention		KA2  KBH 	KBR  KBS 	KC  KAM 	KBC  KBP 	KBJ  KCL 
Single spring loaded lip for general standard pressure fluid sealing and severe grease sealing applications		SA2  SBH 	SBR  SBS 	SC  SAM 	SBC  SBP 	SBJ  SUA2 
Single spring loaded lip with dust lip for general standard pressure fluid sealing and severe grease sealing applications, secondary lip is designed for light duty exclusion of foreign materials		TA2  TBH 	TBR  TCL 	TC  T11 	TBC  TC8 	TBJ  TC9 
Dual spring loaded lips, typically used to separate two fluids but can also be used in high contamination situations to keep out foreign materials and to retain fluid		DA2  DBR 	DC 	DBC 	DAP 	
Triple flat lips for general standard pressure grease retention with heavy duty exclusion of mud and water, commonly used in agricultural equipment		UA2  UBR 	UC 	UB10 	UA20 	
Single spring loaded lip with inverted dust lip for general standard pressure fluid sealing and severe grease sealing applications, inverted lip is designed as a grease retainer allowing for pre-lubrication of seal		XA2  XBR 	XC 	XBC 	XBP 	
External lip seals designed to press-fit on shaft or spindle with sealing element contacting bore, all may be used with lip facing outward to exclude dirt and allow purging		OSB2  OTB2 	OVB2 	OKB2 	OUC 	
This style of lip is used for scraping and wiping in hydraulic and pneumatic cylinder applications		WPC  WPR 	WPK 	WPB2 		

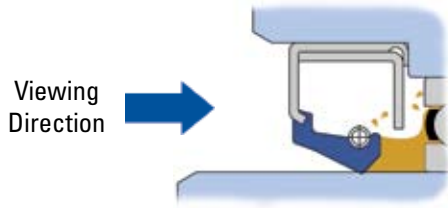
Operations Table

Recommended Operating Conditions

Maximum Shaft Dynamic Runout (DRO)		Maximum Shaft to Bore Misalignment (STBM)		Maximum Pressure		Maximum Shaft Surface Speed			
TIR	RPM	STBM	FPM (MPM)	PSI (BAR)	FPM (MPM)	FPM (MPM)	R.P.M. for Given Shaft Size		
							1" (25.4mm)	2" (50.8mm)	3" (76.2 mm)
0.003" 0.08 mm	0-2000 0-2000	0.005" 0.13 mm	0-2000 (0-610)	3 (0.21)	0-2000 (0-610)	2000 (610)	7639	3820	2546
0.003" 0.08 mm	0-2000 0-2000	0.005" 0.13 mm	0-2000 (0-610)	3 (0.21)	0-2000 (0-610)	2000 (610)	7639	3820	2546
0.020" 0.51 mm	0-1000	0.015" 0.38 mm	0-1000 (0-305)	10 (0.69)	0-1000 (0-305)	3600 (1097)	13751	6875	4584
0.015" 0.38 mm	1000-2500	0.010" 0.25 mm	1000-3600 (305-1097)	5 (0.34)	1000-2000 (305-609)				
0.010" 0.25 mm	2500-4500			0 (0)	2000-3600 (610-1097)				
0.020" 0.51 mm	0-1000	0.015" 0.38 mm	0-1000 (0-305)	10 (0.69)	0-1000 (0-305)	3600 (1097)	13751	6875	4584
0.015" 0.38 mm	1000-2500	0.010" 0.25 mm	1000-3600 (305-1097)	5 (0.34)	1000-2000 (305-609)				
0.010" 0.25 mm	2500-4500			0 (0)	2000-3600 (610-1097)				
0.010" 0.25 mm	0-1000	0.010" 0.25 mm	0-1000 (0-305)	10 (0.69)	0-1000 (0-305)	2000 (610)	7639	3820	2546
0.005" 0.13 mm	1000-2500	0.005" 0.13 mm	1000-2000 (305-610)	5 (0.34)	1000-2000 (305-610)				
0.003" 0.08 mm	0-2500	0.010" 0.25 mm	0-500 (0-152)	3 (0.21)	0-500 (0-152)	500 (152)	1910	955	637
0.020" 0.51 mm	0-1000	0.015" 0.38 mm	0-1000 (0-305)	10 (0.69)	0-1000 (0-305)	3600 (1097)	13751	6875	4584
0.015" 0.38 mm	1000-2500	0.010" 0.25 mm	1000-3600 (305-1097)	5 (0.34)	1000-2000 (305-609)				
0.003" 0.08 mm	0-2500	0.010" 0.25 mm	0-500 (0-152)	3 (0.21)	0-500 (0-152)	500 (152)	1910	955	637
		0.008" 0.20 mm	0-200 (0-60)	4 (0.28)	0-200 (0-60)	linear velocity 200 (60) maximum stroke length 78" (1.98 m)			



Hydrodynamic Aid Designs



Parameter	Hydrodynamic Aid
Shaft only rotates in clockwise direction.	Type "R"
Shaft only rotates in counter-clockwise direction.	Type "L"
Shaft rotates in both clockwise and counter-clockwise directions.	Type "U"

 <u>R</u>	 <u>R4</u>	 <u>U</u>	 <u>U1</u>
 <u>L</u>	 <u>L4</u>	 <u>U2</u>	 <u>U3</u>
 <u>U5</u>	 <u>U6</u>	 <u>U8</u>	 <u>U9</u>
 <u>U10</u>	 <u>U12</u>	 <u>U14</u>	 <u>U15</u>

For more information on hydrodynamic aids refer to page 30B or contact ESP Engineering

Shaft Specifications

Shaft Material: SAE 1035 or 1045

For a seal to reach maximum performance it is best to use a medium to high carbon steel such as SAE 1035 or 1045.

Chrome or nickel plating can provide a hard surface and prevent corrosion in harsh environments. Brass,

bronze, aluminum, zinc, magnesium and other soft metals should not be used due to the excessive shaft wear and grooving. Hardened wear sleeves of mild steel should be pressed over the shaft if these materials are used.

Shaft Hardness: Rockwell C30

The seal contact area of the shaft should be hardened to a minimum of Rockwell C30 under normal conditions. There is no conclusive evidence that a hardness above C30 will improve wear resistance except under

extreme abrasive conditions. A Rockwell hardness of C45 or higher is recommended if the shaft is subject to being nicked by handling prior to assembly.

Shaft Surface Finish: 10-20 Micro Inches

Seal leakage in some applications could be directly linked to such shaft imperfections as machining lead. Therefore, machine lead is held to a tight tolerance of $0^\circ \pm 0.05^\circ$. Seal countersurfaces should be plunge ground to 10-20 micro-inches Ra roughness (0.25-0.50 micrometers) in order to create satisfactory sealing performance.

Machining Lead: $< 0^\circ \pm 0.05^\circ$

Grinding Chatter: No grinding chatter allowed > 45 cycles

Roundness: Out of roundness must be less than 0.0002" (0.00508 mm) and a minimum number of lobes

Lobing: Maximum of 7 lobes at 0.0001" (0.00254 mm)

Shaft Chamfer or Lead In Radius: Figure 10

A shaft should always have a burr free lead-in chamfer or radius to prevent damage to radial shaft seal during installation. The chamfer or radius allows the seal to change from its free diameter to the installed diameter

without the sealing lip rolling or tearing. If a shaft does not have the recommended lead-in chamfer or radius, an assembly cone should be used during installation (see Installation Methods, page 63D).

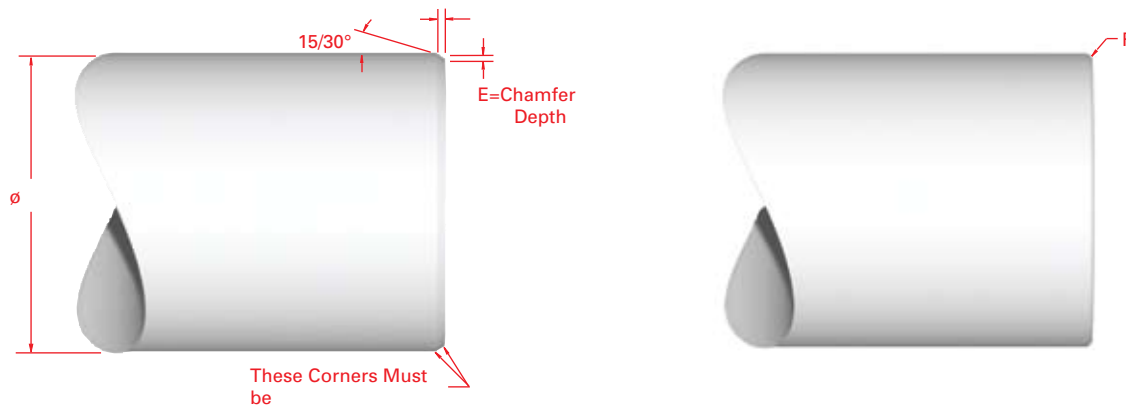


Figure 10: Lead in Chamfer or Radius Specifications

Shaft Dia. \varnothing SD (inches)	E	R	Preferred SCL@15°	Optional SCL@30°
Up to 4.000	0.093	0.188	0.347	0.156
4.001 to 7.000	0.125	0.250	0.466	0.218
7.001 to 40.000	0.188	0.375	0.702	0.323
40.001 and up	0.250	0.500	0.933	0.433

Shaft Dia. \varnothing D1 (millimeters)	E	R	Preferred SCL@15°	Optional SCL@30°
Up to 100.0	2.5	4.5	8.5	4.0
100.1 to 180.0	3.0	6.0	11.5	5.0
180.1 to 1000.0	5.0	9.5	18.0	8.0
1000.1 and larger	6.5	12.7	24.0	11.0

Shaft Specifications

Shaft Tolerance

Shaft tolerances are normally held tight because they are often used in conjunction with bearings or bushings. In general applications, be sure the shaft diameter is within the following recommended tolerances. The tolerance range should be decreased for high speed or high pressure applications.

Shaft Diameter (inches)	Tolerance
Up to and including 4.000	± 0.003
4.001 to 6.000	± 0.004
6.001 to 10.000	± 0.005
10.001 and larger	± 0.006

Shaft Diameter (millimeters)	Tolerance
Over 6 to 10	+0.000 / -0.090
Over 10 to 18	+0.000 / -0.110
Over 18 to 30	+0.000 / -0.130
Over 30 to 50	+0.000 / -0.160
Over 50 to 80	+0.000 / -0.190
Over 80 to 120	+0.000 / -0.220
Over 120 to 180	+0.000 / -0.250
Over 180 to 250	+0.000 / -0.290
Over 250 to 315	+0.000 / -0.320
Over 315 to 400	+0.000 / -0.360
Over 400 to 500	+0.000 / -0.400

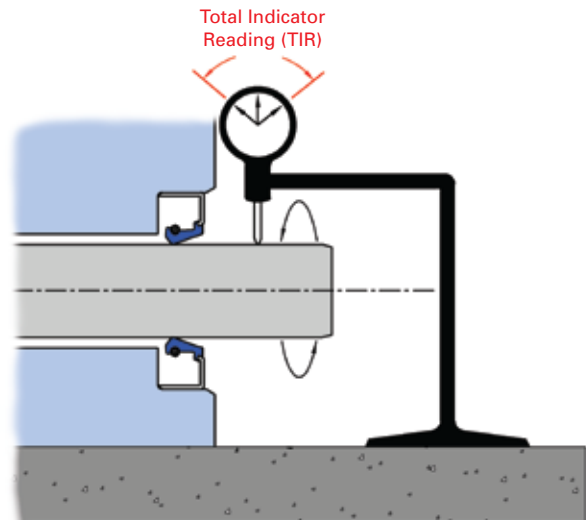
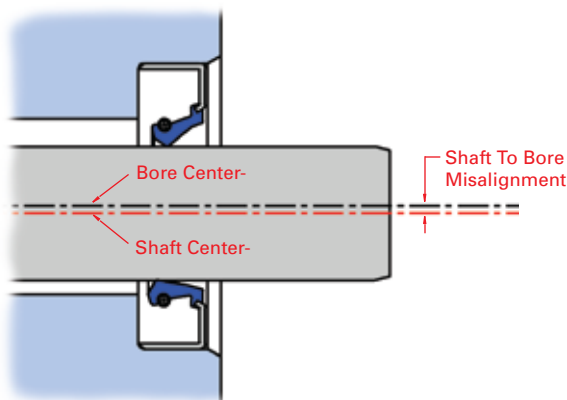
Shaft Eccentricity

To ensure a high performing radial shaft seal, Shaft-To-Bore Misalignment (STBM) and Dynamic Run-Out (DRO) should be kept to a minimum.

STBM is the amount by which the shaft is off center with respect to the bore's center. STBM is caused by machining and assembly inaccuracies. To measure, attach a dial indicator to the shaft (between shaft and bore), rotate the shaft and read the indicator. STBM is HALF the Total Indicator Reading (TIR).

DRO is the amount by which the shaft does not rotate around the true center. Misalignment, shaft bending, lack of shaft balance and other manufacturing inaccuracies are common causes. To measure, slowly rotate the shaft and read the TIR of a dial indicator as shown below.

See the **Operations Matrix** on page 56D for specifications.



Bore Specifications

Bore Material

Ferrous metal such as steel and cast iron are acceptable, but aluminum and plastic housings may also be used. If an aluminum or plastic housing is used, then a rubber O.D. radial lip seal is recommended due to the

differences in thermal expansion between the seal and the housing. Rubber, having a higher thermal expansion than carbon steel, will tighten in the bore as the temperature rises.

Bore Surface Finish: 100 micro-inches

Excessively rough bore finishes may allow paths for fluid to leak between the radial lip seal O.D and bore. For metal O.D. radial lip seals, a maximum bore finish of approximately 100 micro-inches (2.5 micro-meters) should be maintained to avoid leakage. For rubber O.D. radial lip seals, a maximum bore finish of approximately

150 micro-inches (3.75 micro-meters) should be maintained to avoid leakage. Rubber will conform to the housing roughness and allows the rubber O.D. radial lip seal to function with a rougher finish.

Bore Chamfer and Depth: Figure 11

The bore should always have a burr free lead in chamfer to allow for problem free installation of the radial shaft seal. The inside corner should have a maximum radius of 0.03" (0.8 mm).

Bore Hardness

No specific hardness is recommended; however, bore hardness should be high enough to maintain interference with the seal's outside diameter after it is installed. If the bore is too soft and a seal is installed, the material in the bore will likely be abraded away, allowing the seal to be installed, but there is no longer an interference fit with the bore.

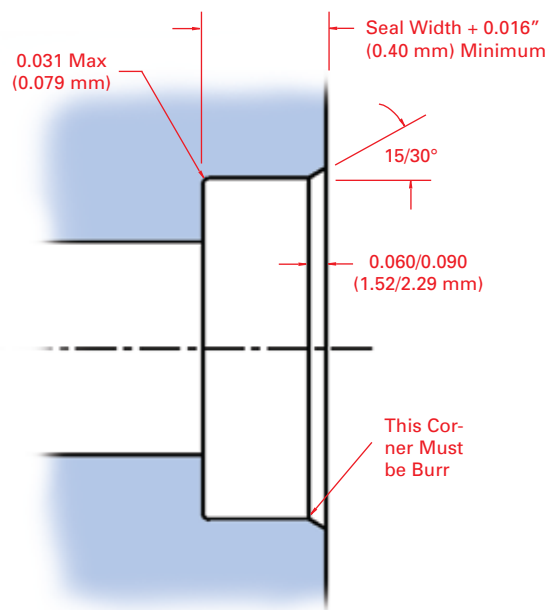


Figure 11: Bore Chamfer and Depth Specifications

Bore Tolerance

The interference between the radial shaft seal and bore is controlled by the bore and seal O.D. tolerance. A seal's press-fit is designed according to the following standard.

Bore Diameter (inches)	Tolerance
Up to and including 2.000	±0.001
2.001 to 3.000	±0.001
3.001 to 5.000	±0.0015
5.001 to 7.000	±0.0015
7.001 to 12.000	±0.002
12.001 to 20.000	+0.002 / -0.004

Bore Diameter (millimeters)	Tolerance
Over 6 to 10	+0.022 / -0.000
Over 10 to 18	+0.027 / -0.000
Over 18 to 30	+0.033 / -0.000
Over 30 to 50	+0.039 / -0.000
Over 50 to 80	+0.046 / -0.000
Over 80 to 120	+0.054 / -0.000
Over 120 to 180	+0.063 / -0.000
Over 180 to 250	+0.072 / -0.000
Over 250 to 315	+0.081 / -0.000
Over 315 to 400	+0.089 / -0.000
Over 400 to 500	+0.097 / -0.000

Radial Shaft Seal Inspection Tolerances

Radial Shaft Seal Outside Diameter Tolerance

Bore Dia. (inches)	Press-fit Allowance		Tolerance	
	Metal Case	Rubber Covered Case	Metal Case	Rubber Covered Case
Up to 1.000	+0.004	+0.006	+0.002 / -0.002	+0.003 / -0.003
1.001 to 2.000	+0.004	+0.007	+0.002 / -0.002	+0.003 / -0.003
2.001 to 3.000	+0.004	+0.008	+0.002 / -0.002	+0.003 / -0.003
3.001 to 4.000	+0.005	+0.010	+0.002 / -0.002	+0.004 / -0.004
4.001 to 6.000	+0.005	+0.010	+0.003 / -0.002	+0.004 / -0.004
6.001 to 8.000	+0.006	+0.010	+0.003 / -0.002	+0.004 / -0.004
8.001 to 10.000	+0.008	+0.010	+0.004 / -0.002	+0.004 / -0.004
10.001 to 20.000	+0.008	+0.010	+0.006 / -0.002	+0.004 / -0.004

Radial Shaft Seal Outside Diameter Tolerance

Bore Dia. (millimeters)	Press-fit allowance		Permissible Eccentricity
	Metal Case	Rubber Covered Case	
Up to 50.0	+0.20 / +0.10	+0.30 / +0.15	0.25
50.1 to 80.0	+0.23 / +0.13	+0.35 / +0.20	0.35
80.1 to 120.0	+0.25 / +0.15	+0.35 / +0.20	0.50
120.1 to 180.0	+0.28 / +0.18	+0.45 / +0.25	0.65
180.1 to 300.0	+0.30 / +0.20	+0.45 / +0.25	0.80
300.1 to 500.0	+0.35 / +0.23	+0.55 / +0.30	1.00

Radial Shaft Seal Width Tolerance

Units	Width Range	Tolerance
Inches	all	+0.015 / -0.015
Millimeters	Up to 10	+0.20 / -0.20
Millimeters	Over 10	+0.30 / -0.30

Installation Methods

The subject of installation represents an area commonly overlooked when selecting a radial shaft seal for application. Improper installation methods are a major cause of premature seal failure. The most expertly designed and manufactured seal will not function properly if the axial and radial alignment are not correct. Refer to **Shaft and Housing Assembly** on pages 23 and 24 for further discussion on proper alignment.

An installation tool should always be used when installing a radial shaft seal. The use of a tool improves ease of installation and reduces the possibility of seal cocking (non-perpendicular to shaft). A hydraulic or pneumatic press is advised to supply necessary force to

install the seal.

Post-Installation Tips

When painting, be sure to mask the seal. Avoid getting paint on the lip or the shaft where the lip rides. If the paint is to be baked on or the mechanism otherwise subjected to heat, the seals should not be heated to temperatures higher than their materials can withstand. In cleaning or testing, do not subject seals to any fluids or pressures that could damage them. When in doubt,

Installation Checklist

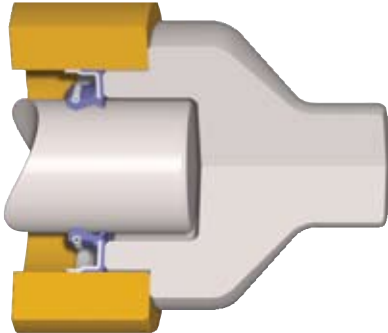
- Bore:** Verify the proper chamfer, remove any burrs or nicks
- Shaft:** Verify proper lead in chamfer on end of shaft. Remove any burrs nicks, grooves or lead that could come in contact with the seal.
- Splines and Keyways:** Sharp edges should be covered with a lubricated assembly sleeve, shim stock or tape to protect the seal lip.
- Component Specifications:** Check all components that come in contact with the seal and verify proper dimensions within tolerances, surface roughness and hardness.
- Part Interference:** Verify that other machine parts do not rub against the seal, causing friction and damaging heat.
- Radial Shaft Seal:** Visually inspect seal for cuts, nicks or other damage.
- Seal Direction:** If replacing an existing seal, face in the same direction. Otherwise, generally, the lip faces the media being sealed.
- Pre-Lubrication:** It is common practice to use lubrication to aid in installation for both the I.D. and O.D. of a seal. This is also beneficial for initial startup for the primary lip in application.
- Correct installation tool (page 64D):** Press-fitting tools should have an outside diameter approximately 0.010" (0.25mm) smaller than the bore size. For best results, the center of the tool should be open so pressure is applied only at the seal outer edge.
- Improper Driving Tool:** Use proper driving tool such as a soft-face tool arbor press or soft workpiece (wood). To avoid cocking the seal, apply force evenly around the outer edge.
- Avoid Cocking:** Bottom out the tool on the shaft, the housing or bottom out the seal in the housing counterbore.

Installation Methods

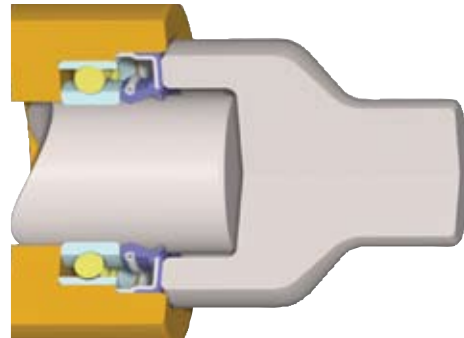
Acceptable Installation Methods

Press-fitting tools should have an outside diameter approximately 0.010" (0.25 mm) smaller than the bore

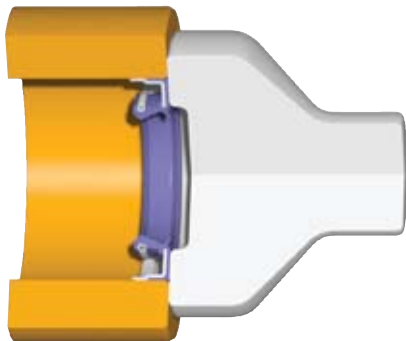
size. Never press directly against the sealing element to seat it in the bore.



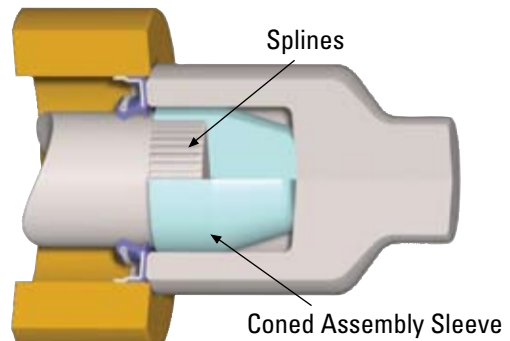
Housing Surface Stop Installation: Machined face of installation tool bottoms on machined housing face.



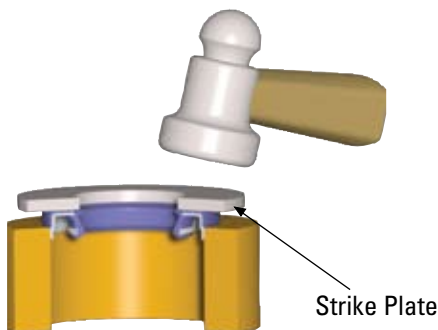
Housing Stop Installation: Seal bottoms on interior shoulder of bore.



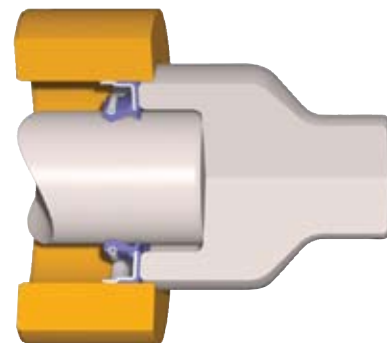
Surface Stop Installation: Installation tool bottoms on machined housing face.



Installation of Seal Over Splines: A thin walled lubricated assembly sleeve prevents damage to seal lip from splines, keyways and unchamfered shafts.



Strike Plate Installation: Face of strike plate bottoms on machined housing face. Care must be taken to insure proper seal to bore alignment while seal is being installed.



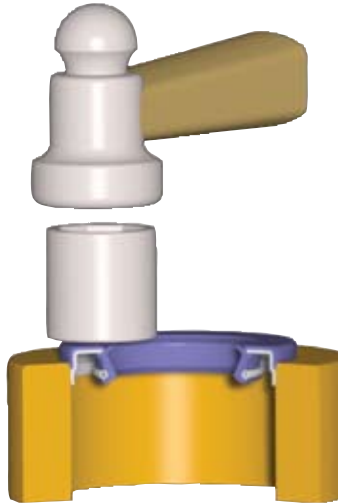
Shaft Stop Installation: Installation tool bottoms on shaft.

Installation Methods

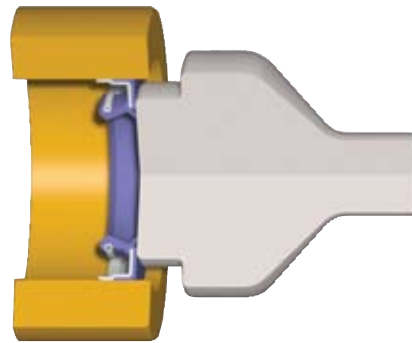
Unacceptable Installation Methods

Following are schematics of common improper installation procedures. These methods are presented because they are commonly seen and not recognized as being incorrect in the industry. Proper seal installation is of utmost importance. If a seal is improperly installed, it could be deformed or severely damaged, greatly

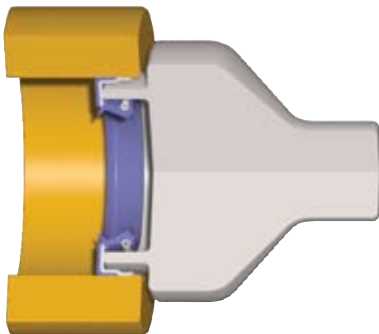
reducing its life. Typically, when a seal is not properly installed, it will be cocked in the bore. This causes one side of the sealing lip to have greater interference with the shaft, leading to uneven wear and premature radial shaft seal failure.



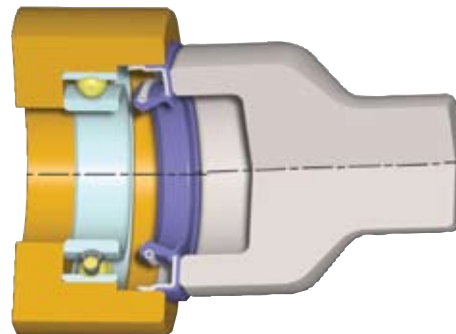
Improper Driving: Always use a type of driving ring to install the seal. Without it, localized seal deformation may occur.



Undersized Installation Tool: Driving diameter of installation tool is too small, seal deformation may occur.



Poorly Engineered Installation Tool: Seal deformation may occur. In this situation the installation tool should be designed similar to the Surface Stop Installation tool.



Misalignment Errors: Centerline of tool and bore do not coincide, causing seal to deform or to be cocked in the bore, providing a leak path for the media being sealed.

