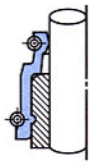
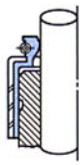
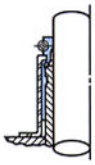
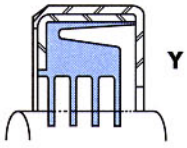
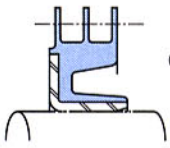
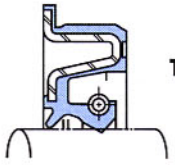
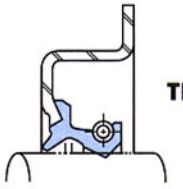
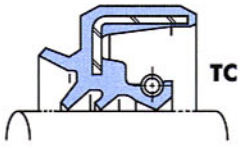
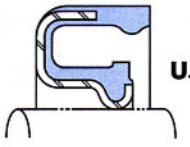
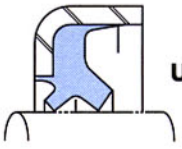
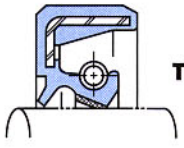
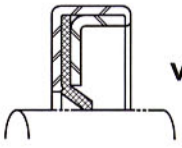
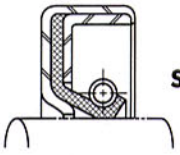
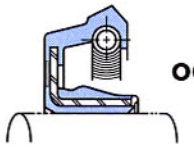
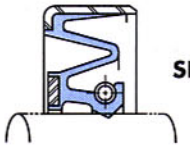
NONSTANDARD DESIGNS

For oil seal designs not shown, please contact Freudenberg-NOK for recommended designs to meet your application requirements.

TABLE 5 (cont.)

DESIGN TYPE	APPLICATION	EXAMPLE		
VS	Valve Stem Seals	 VSW	 VSB	 VSB5
V	Special Mud Seals	 Y	 OY	
"5"	Flange Seals	 TC 5	 TB 5	
"9"	Side Lip Seal	 TC 9		
"UJ"	Universal Joint Seals	 UJ	 UJB	
"J"	PTFE Seals	 TCJ	 VAJ	 SA1J
"O"	Rotating Bore	 OC		
"E"	High Shaft Eccentricity	 SBE		

SHAFT RECOMMENDATIONS

SHAFTS

Seal and shaft compatibility is dependent on four conditions: shaft tolerance, lead-in chamfer, finish and hardness. Proper consideration of these conditions will assist in providing optimal seal performance.

- **SHAFT HARDNESS** is an important factor to prevent excessive wear, deformation, scratches or nicks, and to allow for easy machining for proper roughness. Under normal conditions, **the seal contact area of the shaft should be Rockwell C45 minimum.**

- **SHAFT SURFACE ROUGHNESS** is very important as this greatly influences the amount of lip wear. The recommended roughness is as follows:

  - Rotating 10 to 20 μ inch Ra (.25 μM to .50 μM Ra): R_{MAX}=31-126 μ inch (0.8-3.2 μM)
  - Reciprocating 5 to 10 μ inch Ra (.13 μM to .25 μM Ra)

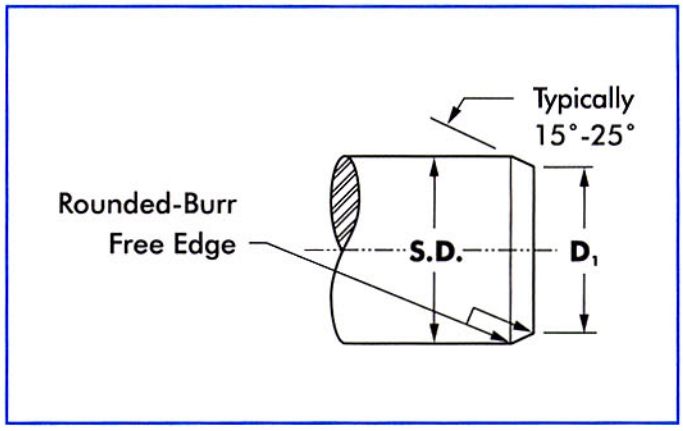
  The method of achieving this finish should not be overlooked.

- **PLUNGE GRINDING** is recommended for rotating shaft applications. For reciprocating applications, centerless grinding is acceptable. Rotating shaft applications require a surface with no machine lead, as machine lead may actually pump fluid from under the seal lip. Also, hard chrome plating is suggested for any cast iron or stainless steel shafts for rotating applications and for steel shafts with reciprocating applications.

- **A SHAFT CHAMFER** is suggested to assist in the installation process. Without a proper chamfer, the seal lip may be damaged or distorted resulting in a dislodged garter spring.

- **SHAFT TOLERANCE** recommendations for general applications are listed in Table 7 below. The tolerance range should be decreased for high speed or pressure applications.

TABLE 6
RECOMMENDED SHAFT CHAMFER



INCHES			
S.D.	**D_1**	**S.D.**	**D_1**
Up to 1.000	S.D. – .094	4.001 to 5.000	S.D. – .220
1.001 to 2.000	S.D. – .140	5.001 to 5.000	S.D. – .260
2.001 to 3.000	S.D. – .166	6.001 to 5.000	S.D. – .276
3.001 to 4.000	S.D. – .196	–	–

MILLIMETERS			
S.D.	**D_1**	**S.D.**	**D_1**
Up to 25.00	S.D. – 2.4	100.01 to 125.00	S.D. – 5.6
25.01 to 50.00	S.D. – 3.6	125.01 to 150.00	S.D. – 6.6
50.01 to 75.00	S.D. – 4.2	150.01 to 250.00	S.D. – 7.0
75.01 to 100.00	S.D. – 5.0	–	–

TABLE 7
RECOMMENDED SHAFT TOLERANCE

SHAFT DIAMETER (INCH)	TOLERANCE	SHAFT DIAMETER (DIN/METRIC)	TOLERANCE
Up to 4.000	±.003	Up to 100 mm	±0.08
4.001 to 6.000	±.004	100.10 to 150.00	±0.10
6.001 to 10.000	±.005	150.10 to 250.00	±0.13

HOUSING RECOMMENDATIONS

HOUSINGS

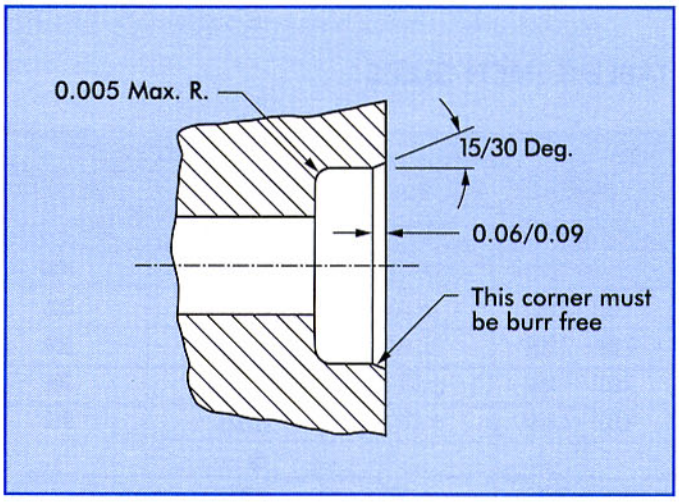
Steel and cast iron provide good surfaces for both rubber covered and metal O.D. seals. For soft alloy (aluminum) bores, rubber covered O.D. seals provide better sealing capability. In aluminum or other soft alloy bores, metal O.D. seals occasionally back out of the bore due to thermal expansion of the soft alloy. Rubber, having a higher coefficient of thermal expansion than carbon steel, will tighten in the bores as temperature rises. Plastic or nylon are not recommended because they typically expand at a high rate causing a major problem for metal O.D. seals. If plastic is to be used, rubber O.D. seals are recommended.

BORE CHAMFER

A bore chamfer is necessary to assist in installation of the seal. To the right is the recommended configuration for the chamfer.

Proper chamfer angle and depth minimizes cocking or lack of squareness of the seal to the shaft, distortion of the seal cases, and reduces assembly force.

RECOMMENDED BORE CHAMFER



SURFACE ROUGHNESS

Excessively rough bore finishes may allow paths for fluid to leak between seal O.D. and bore. Below shows the recommended maximum roughness.

	METAL O.D.	RUBBER O.D.
MAXIMUM ROUGHNESS	100 μM inch Ra	150 μM Ra
	2.50 μM Ra	3.75 μM Ra
	12.5 mm R_{MAX}	
	492 μ inch R_{MAX}	

The rubber O.D. seal is capable of functioning with a rougher finish.

	METAL O.D.	RUBBER O.D.
MAXIMUM ROUGHNESS	None	60 μinch Ra
	None	2.4 μM Ra

A minimum bore roughness is recommended for rubber O.D. seals. This improves retention.

BORE DIAMETER TOLERANCE

The recommended housing bore diameter, bore tolerance and nominal pressfit.

TABLE 8 **INCH SIZES**

BORE DIAMETER	BORE TOLERANCE	NORMAL PRESSFIT		O.D. TOLERANCE (1)		OUT OF ROUND (2)	
		SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.	SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.	SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.
Up to 1.000	±.001	.004	.006	±.002	±.003	.005	.010
1.001 - 2.000	±.001	.004	.006	±.002	±.003	.006	.012
2.001 - 3.000	±.001	.004	.006	±.002	±.003	.006	.014
3.001 - 4.000	±.0015	.005	.008	±.002	±.004	.007	.018
4.001 - 6.000	±.0015	.005	.010	+.003 −.002	±.004	.009	.023
6.001 - 8.000	±.002	.006		+.003 −.002		.012	
8.001 - 9.000	±.002	.007		+.004 −.002		.015	
9.001 - 10.000	±.002	.008		+.004 −.002		.015	

TABLE 9 **EQUIVALENT METRIC SIZES**

BORE DIAMETER	BORE TOLERANCE	NORMAL PRESSFIT		O.D. TOLERANCE (1)		OUT OF ROUND (2)	
		SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.	SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.	SEALS WITH METAL O.D.	SEALS WITH RUBBER O.D.
Up to 25.00	±0.025	0.10	0.15	±0.05	±0.08	0.13	0.25
25.01 - 50.00	±0.025	0.10	0.15	±0.05	±0.08	0.15	0.30
50.01 - 75.00	±0.025	0.10	0.15	±0.05	±0.08	0.15	0.36
75.01 - 100.00	±0.038	0.13	0.20	±0.05	±0.10	0.18	0.46
100.01 - 150.00	±0.038	0.13	0.25	+0.08 −0.05	±0.10	0.23	0.58
150.01 - 200.00	±0.051	0.15		+0.08 −0.05		0.30	
200.01 - 225.00	±0.051	0.18		+0.10 −0.05		0.38	
225.01 - 250.00	±0.051	0.20		+0.10 −0.05		0.38	

(1) Seal O.D. - The average of a minimum three measurements to be taken at equally spaced positions.

(2) Out of Round (OOR) - The maximum variance between any of the readings used in determining seal O.D.