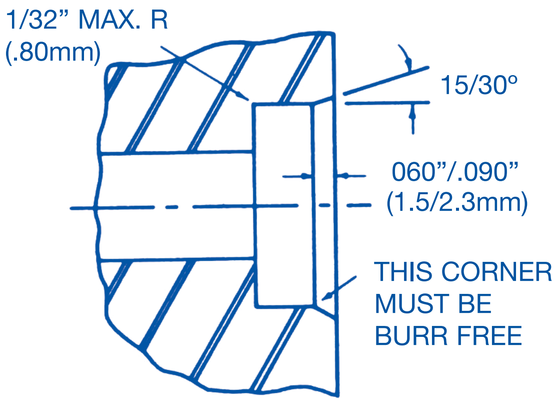
design
criteria for the bore and shaft



Bore Configurations
Tobar's oil seals are designed with an entry lead-in angle on the outside diameter of the seal to provide ease of installation. Additionally, the bore should be designed with a lead-in chamfer to facilitate seal assembly, and protect against damage to the O.D. of the seal. A chamfer of 15º to 30º is recommended at the entry edge of the bore. This chamfer should have a minimum axial depth of .060"/.090" and be free of burrs. The internal corner of the bore should have a maximum radius of 1/32".

Bore Tolerance
Tobar's oil seals are manufactured to tight outside diameter tolerances to insure a positive press-fit seal between the seal O.D. and the bore. Depending upon the size and configuration of the seal, the nominal press-fit of the seal O.D. in the bore will be between .004" and .010". The bore tolerance chart on page 15 will furnish the exact tolerances required for bore design.

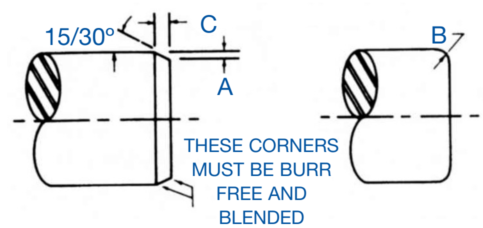
Tolerances on these tables apply to bores fabricated in ferrous materials only. Bores machined in aluminum and other materials of higher coefficients of thermal expansion may require tighter press-fits. Tobar's Type C case and O.D. structured oil seals with rubber covered O.D.'s are recommended when used in conjunction with bores of higher thermal expansion. (The rubber covered O.D. will provide a rate of thermal expansion greater than that of the carbon steel cans thereby helping to ensure a positive press-fit through elevated temperatures.) Additionally, these rubber covered O.D.'s will provide protection against the damage to bores of a softer Rockwell hardness than the carbon steel cans.

Bore Hardness
There is no recommended Rockwell hardness for the bore. However, the bore should be of sufficient hardness to provide and maintain a stable interface for the seal. If the seal is press-fit into a plastic housing whereby the metal O.D. of the seal will be significantly harder than the bore, Tobar recommends a rubber covered outside diameter seal.

Bore Finish
Metal O.D.: Up to 100 micro-inches.
Rubber O.D.: 100 plus micro-inches.

Shaft Configuration
The most demanding function placed on an oil seal is creating the seal between the lip element and the rotating shaft. For this reason the shaft preparation is most critical since it represents 50 percent of the dynamic seal assembly.

A lead-in angle or radius on the shaft is required to ensure against seal damage during installation. The following chart shows recommended chamfers and radii for varying shaft diameters. As with the bore, it is most important to ensure that there are no burrs or sharp edges at the lead-in end of the shaft.



SHAFT DIAMETER				
Shaft (inches)	(A)	(B)	Preferred C@15°	Optional C@30°
Up to 4.000	.093	.188	.347	.156
4.001 to 7.000	.125	.250	.466	.218
7.001 to 40.000	.188	.375	.702	.323
40.001 and larger	.250	.500	.933	.433

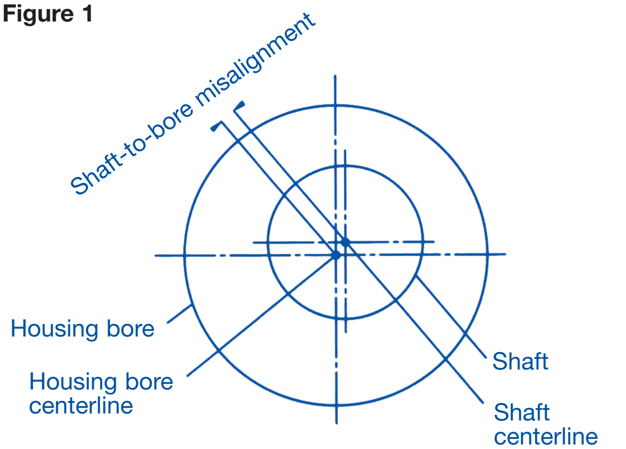
Shaft Material
For the best dynamic seal results, a medium carbon steel shaft of AISI 1035 or 1045 with a hardness of Rockwell 45 (Rockwell C3 minimum) is recommended. Stainless steel shafts can also be utilized successfully. Hard plated surfaces such as chrome-plate or nickel-plate can also be used satisfactorily if the surface finishes are proper. Shafts of brass, bronze, aluminum alloys, zinc, magnesium and other such soft metals are not recommended for normal oil seal application. It may be possible to utilize these softer materials if the dynamic action between the seal and the shaft is very limited.

Shaft Surface Finish
The otimum finish is a plunge grind. To help acheive consistent sealin gperformance and to maximize the life of the seal, we recomment the followin gshaft finish:
RA 0.25 to 0.50 micro-meters (10-20 micro-inch)
Rz 1.65 to 2.90 micro-meters (65-115 micro-inch)

Shaft Eccentricity
Eccentricity between the oil seal and shaft takes two forms: dynamic and static. Static eccentricity is described as the misalignment between the shaft and the bore. That is, the amount the shaft centerline is offset from the bore centerline when both components are in the assembled condition. Non-spring loaded oil seals will handle a static eccentricity of .005 total indicator reading when operating between 0 and 2000 ft. per minute. A spring loaded oil seal will accommodate .015 static eccentricity when operated between 0 and 1000 ft. per minute and .010 static eccentricity when operating between 1000 and 3600 ft. per minute.

Figure 1
Dynamic eccentricity is described as the misalignment created by the shaft not rotating about its true center-line. This is produced by a bent shaft, an improperly supported shaft, or a shaft with high side loads. A non-spring loaded oil seal will accommodate dynamic eccentricity of .003 total indicator reading when operated between 0 and 2500 ft. per minute. A spring loaded oil seal will handle .020 total indicator reading when operated between 0 and 1000 ft. per minute, .015 total indicator reading when operated between 1000 and 2500 ft. per minute, and .010 when operated between 2500 and 4500 ft. per minute.

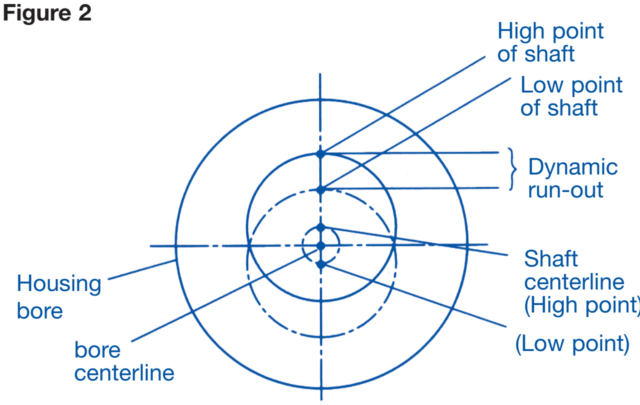
Figure 1



Shaft to bore Misalignment
The distance that the center of the shaft rotation is from the center of the bore.

Figure 2
Seals with increased width are more capable of handling both dynamic and static eccentricities. This is a result of the seal's increased beam length, and the resulting lack of resistance within the seal lip to following the eccentric motion of the shaft surface.

Figure 2



Dynamic run-out
Dynamic run-out is calculated as twice the distance that the center of the shaft is displaced from the actual center of rotation.

Shaft Tolerance Chart
The following chart shows the recommended shaft tolerance for use with Tobar oil seals. Other requirements in the overall design may require tighter tolerances for the shaft than are shown in this chart.

INCHES	
Nominal Shaft Diameter	Tolerances
Up to and including 4.000	±.003
4.001 to 6.000	±.004
6.001 to 10.000	±.005
10.001 and larger	±.006

Design Exceptions
The design recommendations in this catalog are only suggestions and do not imply that designs outside of these recommendations will not function. Tobar recommends, in all cases, that thorough functional testing be conducted on all designs to ensure their success. Trade-offs between temperature, pressure, shaft speed, eccentricity, and seal style to handle conditions beyond those stated in this cat-alog may be possible. However, care and thorough testing are recommended for satisfactory results.