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REVISED OCTOBER, 1967

Parker O-RING...

HANDBOOK...

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

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Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

STATIC SEAL

It has been said that O-rings are "the finest static seals ever developed." Perhaps the prime reason for this is because they are human proof. No adjustment or human factor comes into play when O-rings are assembled originally or used in repairs if the gland has been designed and machined properly. O-rings do not require high bolt torques to seal perfectly. O-rings are versatile and save space and weight. They seal over an exceptionally wide range of pressures, temperatures and tolerances. Once seated, they continue to seal even though some feel that they theoretically should not. In addition to all this, they are economical and easy to use. Therefore, we agree that the O-ring is "the finest static seal ever developed".

The Static Seal Design Charts and Tables of Sections 7 and 8 are based on accepted practice and should be used whenever possible. The following example illustrates the use of the Design Charts:

Problem: To design an industrial static seal male gland for $1.000 {}^{+.002}_{-.000}$ ID bore (dia. "A") at 1500 psi.

Procedural Step	**Example**
Select O-ring with nominal OD of 1 inch	Parker No. 2-020
Determine gland depth L from Design Chart 8-2	0.050 to 0.052
Calculate groove dia., B-1	
(B-1 min = A max — 2L max)	B-1 min = 1.002-2 (0.052) = 0.898
	B-1 max = 1.000-2 (0.050) = 0.900
(B-1 max = A min — 2L min)	B-1 = $0.900 {}^{+.000}_{-.002}$
Determine diametral clearance, E from Chart 8-2	0.002 to 0.005
Calculate plug dia., C.	C min = 1.002 — 0.005 = 0.997
(C min = A max — E max)	C max = 1.000 — 0.002 = 0.998
(C max = A min — E min)	C = $0.998 {}^{+.000}_{-.001}$
Determine groove width, G from Chart 8-2.	0.093 to 0.098 (no back-up ring required for 1500 psi.)

In table 8-2, gland dimensions have been calculated by this process for each standard 2-O-Ring size. The procedure outlined above will be particularly useful in determining gland dimensions for special O-Ring sizes or for standard O-Ring sizes with different stretch from those suggested in the table.

The need for back-up rings should be investigated for pressures exceeding 1500 psi (true for all seal types). If there is no extrusion gap, back-up rings are not required. Very high pressures can be sealed without back-up rings if metal-to-metal contact (practically zero clearance) of the gland parts can be maintained. Instances have been reported of sealing pressure of 200,000 psi with a 70 durometer O-ring without back-up rings. Vibration or pressure fluctuation sometimes will produce breathing which requires back-up rings at average pressures below 1500 psi.

When using silicone O-rings, the clearance given in Sections 7 and 8 should be reduced 50%.

Wherever possible, design the gland parts to accomplish the following:

1. Use the system pressure to close clearance gap.

Figure 5-1. End Cap Seal

2. For end caps or face seals, design the Groove O.D. to be the same as the OD of the O-ring if the pressure is from the inside. This minimizes pumping leakage and abrasive wear which occurs when the O-ring is installed against the groove ID. With the rise and fall of pressure, the O-ring moves to and from the groove OD and wear and leakage result.
3. Added wall support on plug seal minimizes breathing. External threads prevent O-ring damage during assembly.

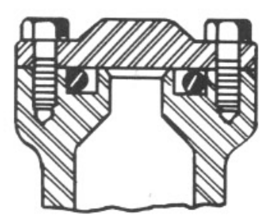

Figure 5-2. Face Seal

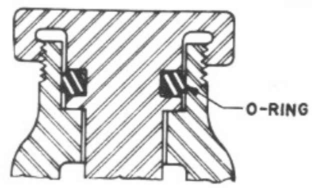

Figure 5-3. Plug Seal

DOVE TAIL GROOVE

It is often necessary to provide some means for holding an O-ring in a face seal groove during assembly and maintenance of equipment. An undercut or dovetail groove has proven beneficial in many applications to keep the O-ring in place. This is an expensive groove to machine and thus should be used only when absolutely necessary.

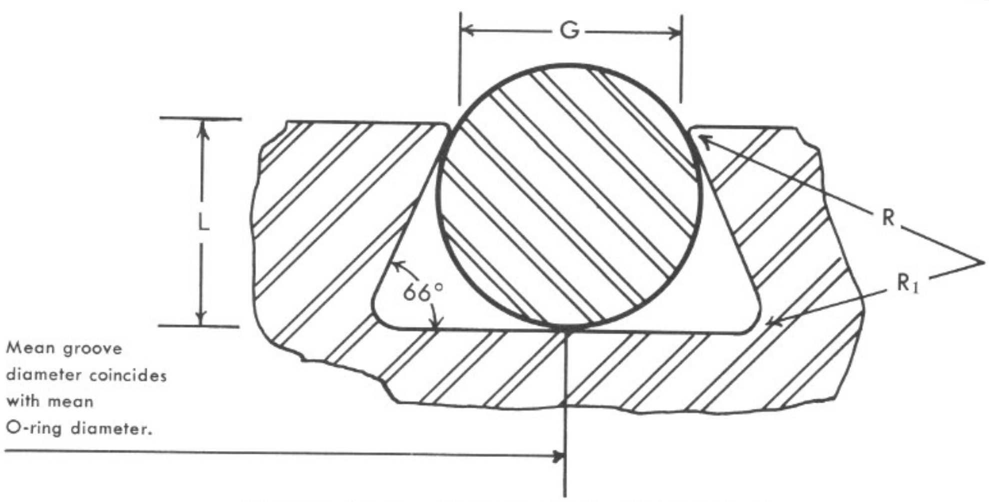

TABLE 5-1—DOVE TAIL GROOVES

Parker O-ring Size 2-	W O-ring Cross section		L Gland Depth	G Gland Width (To Sharp Corner)	R	R_1
	Nominal	Actual				
004 thru 050	1/16	.070	0.050/0.052	0.055/0.059	0.005	1/64
110 thru 178	3/32	.103	0.081/0.083	0.083/0.087	0.010	1/64
210 thru 284	1/8	.139	0.111/0.113	0.113/0.117	0.010	1/32
325 thru 395	3/16	.210	0.180/0.183	0.171/0.175	0.015	1/32
425 thru 475	1/4	.275	0.231/0.234	0.231/0.234	0.015	1/16

Radius "R" is critical. Insufficient radius will cause damage to the seal during installation while excessive radius may contribute to extrusion.

VACUUM SEAL

O-rings are becoming increasingly popular as sealing devices in vacuum applications. O-ring compounds and gland designs have been developed primarily for static face seals.

The vacuum gland should be almost completely filled by the O-ring. Care should be taken, however, to make sure that the O-ring cross sectional area is not more than 1% greater than gland (cross section) area under any tolerance conditions. This amount of excess will not volumetrically overfill the gland cavity. The nearly filled gland is necessary in a vacuum system because some shrinkage is encountered with almost any rubber compound and no seal motion can be tolerated. If the seal is once unseated (by pressure or motion) it is difficult to get many rubbers to reseat while under vacuum.

Smoother than normal gland surface finishes may be needed if high vacuum is involved.

Vacuum sealing is probably the most difficult of all to accomplish. This is due to the fact that the molecules being sealed are exceptionally small, gas is expandable and minute leakage, normally not detectable in other systems, cannot be tolerated. All rubbers tend to shrink a small amount and very low pressures are always more difficult to seal.

Table 5-2 presents values for the permeability of typical reinforced elastomers to gasses. The table shows the advantage of using butyl, nitrile or neoprene compounds over GR-S and natural rubber.

TABLE 5-2—GAS PERMEABILITY OF ELASTOMERS

These values multiplied by 10^{-8} give the number of cubic centimeters of the gas, measured at atmospheric pressure and the listed test temperature, which will permeate through one square centimeter of the elastomer, one centimeter thick in one second with one atmosphere differential pressure across the specimen.

	Nitrile		GR-S		Natural		Neoprene		Butyl	
	77°F	122°F	77°F	122°F	77°F	122°F	77°F	122°F	77°F	122°F
Oxygen	3.2	10.5	13.0	34.5	18.0	49.5	3.0	10.0	0.30	1.00
Nitrogen	0.89	3.7	4.8	14.5	6.6	22.5	0.89	3.55	0.11	0.35
Carbon Dioxide	23.0	66.0	94.0	195.0	102.0	220.0	19.5	56.5	0.03	0.10
Methane	2.4	10.1	16.0	43.0	22.0	64.0	2.5	9.8	0.01	0.33
Hydrogen	11.5	31.5	30.5	74.0	39.0	97.0	10.3	28.5	0.03	0.10

Condensed from G. J. Van Ameronger, "The Permeability of Different Rubbers to Gases and Its Relation to Diffusivity and Solubility." Journal of Applied Physics, 1946 and Rubber and Chemistry and Technology, 1947.

Most vacuum applications in the range of 10^{-4}mm Hg can be sealed successfully with a standard industrial compound. Parker compounds N219-7 and N525-6 are being used. In the region of "hard vacuum," below the level of 10^{-6}mm Hg, outgassing and/or sublimation of the rubber may occur. Fluorocarbon rubber compound 77-545 will withstand vacuum down to at least 10^{-9}mm Hg. Table 5-3 presents values for selected Parker compounds for service in this region.

TABLE 5-3—WEIGHT LOSS OF ELASTOMERS

Parker Compound No.	Base Polymer	Pressure mm Hg	Weight Loss %	Remarks
B318-7	Butyl	1×10^{-7}	2.0	
B318-7	Butyl	2×10^{-8}	31.0	Large weight loss shows sublimation
77-545	Viton	1.8×10^{-9}	2.1	Especially recommended for very hard vacuum

Determined on microtome samples at 77° F, 84 Hours.

For designing vacuum seals in industrial components, use Table 5-4. The narrower grooves minimize the pumping action of the O-ring and insure more positive sealing. For more sophisticated equipment a more complete fill can be utilized as described in second paragraph of page 5-4.

TABLE 5-4—VACUUM STATIC SEAL GROOVES

Parker O-Ring Size 2–	W O-Ring Cross section		Gland Depth	Gland Width
	Nominal	Actual		
004 thru 050	1/16	.070	0.050/0.052	0.083/0.088
110 thru 178	3/32	.103	0.074/0.076	0.118/0.123
210 thru 284	1/8	.139	0.101/0.103	0.157/0.163
325 thru 395	3/16	.210	0.152/0.155	0.236/0.241
425 thru 475	1/4	.275	0.201/0.204	0.305/0.310

It is permissible, and sometimes very desirable, to use two or more O-rings in separate grooves for vacuum seals. Problems due to pressure trapping normally do not arise, since the maximum pressure differential is atmospheric and the leakage is compressible gas.

If the O-ring is to seat and seal properly, lubrication must be provided for assembly of all vacuum seals. For vacuum grease, contact factory as rapid advances are being made in this field.

Note: For additional information on vacuum sealing, see Parker Seal Compound Manual C5702 and Gask-O-Seal Handbook G5411.

FAILURES AND LEAKAGE

By far the most common type of failure of static seals is extrusion. This is relatively easy to prevent if the curves (see figure 4-3) are used when the unit is designed.

Pumping leakage occasionally occurs when the pressure alone causes the O-ring to roll in the groove and the resilience of the seal returns it to its original position. To avoid pumping leakage, design the gland so that the normal position of the seal cross section will be on the low pressure side of the gland or use a narrower groove.

Porous castings, eccentric grooves, out of tolerance parts, tool marks, and distorted or breathing glands are also frequent contributors to static seal malfunctioning (see Sections 1 and 2).