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Sealing Techniques for Missile Applications

FOREWORD

Changes in this Revision are format/editorial only.

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1. SCOPE:

The purpose of this standard is to provide the missile hydraulic and pneumatic component designer with information learned, tested and substantiated in correction of problems and failures experienced with seals that are subject to the unique requirements of missile static storage and subsequent dynamic operational conditions.

Missile hydraulic and pneumatic component designers have been handicapped by the absence of concise design criteria for two difficult sealing conditions usually existing in missile applications as follows:

- Static pressure condition - Low pressure for long periods in a cyclic temperature environment (i.e., long term storage requirements).
- Dynamic pressure condition - High pressures suddenly applied in an extreme temperature environment (i.e., operational firing requirement).

Each of the two conditions listed above are frequently required to be satisfied by a single seal in a missile hydraulic or pneumatic component with sealing requirements changing abruptly from the first to the second set of conditions.

This design standard is intended to facilitate more nearly optimum designs by presenting specific recommendations in the areas of materials, finishes, configurations and inspection criteria that past experiences show to be desirable and prudent.

2. ELASTOMERIC O-RING SEAL GUIDELINES:

2.1 General Introduction:

The O-ring is widely used as a seal element in a broad range of missile hydraulic and pneumatic component designs. It has been variably successful as attested by a continuing family of problems and failures associated with seal designs especially in low temperature and low pressure long term storage applications.

In some cases, the problem of failure has been directly attributed to inadequacies of the O-ring as a seal element choice (i.e., a simple misapplication). In other cases, the problem or failure cause was traced to improper choice of O-ring material properties and dimensions; inadequate design features interfacing with the O-ring; damage and abuse; quality controls; and insufficient testing of the design to detect and correct design deficiencies before committing the design to production.

It is essential that the missile hydraulic and pneumatic component designer have a working understanding of the O-ring as a candidate element for seal design; be aware of its functional limitations; and have some guidance for approaching design requirements which are not clearly “cut and dried” in the existing published “cook book” approaches to general O-ring usage.

2.1 (Continued):

This section of the standard is intended to supply information learned, tested and substantiated in the correction of problems and failures experienced with O-rings used in missile hydraulic and pneumatic components.

2.2 Seal Principle Discussion:

The O-ring is made of highly elastic materials, performing its function in the deformed condition through its ability to reliably store elastic energy and use this energy to maintain sealing pressures against mating interfaces.

Mechanical deformation of the O-ring by surrounding structure or by the pressure of confined fluids, individually or in combination, is used to force the material into potential leak paths to provide a positive block to the flow of the confined fluid.

When the O-ring is deformed solely by the preloads applied by mating structure, and the resulting interface pressure is sufficient to provide the effective seal over the full range of functional and storage conditions without being assisted by the confined fluid pressure, it can be considered an ordinary gasket.

When the O-ring is primarily deformed by the pressure forces of the confined fluid, and secondarily by the structural and environmental effects, it must not be treated as a gasket.

The designer using the O-ring element must understand that the difference in deformation mode can be critical to successful sealing.

In low-pressure (below approximately 300 psig), low-temperature (dependent on material) design, the seal interface pressure must be achieved by maintaining adequate structurally applied preload compression in the O-ring, since fluid pressures in this range will usually not adequately deform O-rings made of known materials in the available hardness (durometer) ranges to form a seal.

In pressures ranging above 300 psig, and up to the extrusion pressure of the particular O-ring material choice, the fluid pressure is generally sufficient to deform the O-ring to provide effective interface pressures.

There are some special environmental conditions, such as low temperatures approaching the glass-transition of the material, the effect of which may best be determined by development testing as described herein.

2.3 Common Failure Causes:

Most failures of missile hydraulic and pneumatic component O-ring seals occur at low pressure and at low temperature extremes and can be attributed to any of the following causes:

(a) Insufficient elastomeric force caused by a variety of factors such as:

- inadequate design squeeze (“Squeeze” means change in shape due to surrounding structures, whereas “deformation” may be caused by confined fluid pressures as well).
- excessive compressive set of seal materials
- inadequate durometer rating (i.e., too low)
- inadequate elastic compliance
- inadequate elastic temperature range
- reduction in volume due to migration of material additives

(b) Spiraling of seals during operation in a reciprocating application or during assembly. This condition is generally associated with any of the following:

- inadequate stiffness of the O-ring cross-section
- excessive eccentricity
- inadequate lubrication
- inadequate assembly procedures or aids
- discontinuities and/or protrusions on the flash line
- incompatible surface finishes or conditions
- long stroke cylinders

(c) Contamination lying across the seal contact surfaces

(d) Handling or assembly damage

(e) Molding or processing flaws in the seal

(f) Extrusion of the seal during prior operation or environmental exposure due to either excessive design clearance or structural deformation under pressure

(g) Excessive wear of dynamic seals due to microscopic pits and discontinuities in contacting surfaces such as anodized aluminum

(h) Porosity or other defects in contacting surfaces

(i) Physical properties or dimensions that are not adequately controlled

(j) Improper selection of seal materials and/or lubricants

2.4 Development and Qualification Test Recommendations:

Due to the time and cost constraints, development and qualification tests normally do not evaluate the effects of:

- long term storage and field service
- all possible variations in the material properties
- all possible dimensional and finish variations

Because of the factors above, development tests should selectively include conditions that exceed maximum specified environmental conditions. Marginal seal designs are prone to be revealed by exposure to temperatures that exceed specified extremes followed by leakage tests at:

- low temperature and low pressure
- high temperature and low pressure
- high temperature and high pressure applied suddenly
- low temperature and high pressure applied suddenly

The above tests are intended to encompass all extreme conditions. Usually, the most adverse combination of conditions is exposure to high temperature followed by leakage tests at low temperature (with high pressure applied suddenly).

Development test hardware should exceed design tolerances (i.e., margin excess involves consideration of critical nature of seal, machining capabilities, cost and time constraints) in each of the following areas:

- high diametral clearances
- high gland eccentricities
- rough finishes
- high and low preload “squeeze” conditions

Each vendor elastomeric compound for use should be qualified for specific seal applications. Specific material (i.e., physical characteristics) verification tests should be conducted on each vendor compound along with functional seal qualification tests.

Qualification by “similarity” should not be used to justify omission of functional qualification tests for critical seal applications.

Use of plastic models and leak path isolation fixtures as developmental test beds are important in evaluating sealing effectiveness, problems and failures.

Use of specialized leak detection and measurement equipment (i.e., excellent commercial detectors are available) is invaluable in understanding the margins of seal efficiency.

2.5 Design Guide for High Reliability:

Efforts to achieve high reliability in an O-ring seal design will involve several of the following factors:

- Use of specific vendor elastomeric compounds that have demonstrated overstress margin of sealing qualities during and after exposure to fluids and specified environmental conditions.

- Tightened inspection of critical O-rings for specific types of defects and mechanical properties, and of mating surfaces for dimensions and surface finish.

- Selective deviation from conventional gland dimensions, usually in the direction of increased squeeze and reduced gland volume. This provides increased interface pressure and is especially important in low pressure, low temperature applications. The volume of the gland must be at least equal to the volume of the seal under the worst case condition of seal swell and dimensional tolerance.

- Use of the largest standard O-ring cross-section and the highest standard durometer permitted by available space and by assembly damage considerations. In static low pressure applications, these features facilitate the achieving of higher interface pressures, in conjunction with nonstandard gland dimensions. In reciprocating seal applications, these features minimize the probability of spiraling.[1]

- The selective use of cap strips for reciprocating seal applications. Cap strips offer the advantage of improved wear resistance, reduced extrusion, and reduced friction. Virgin Teflon[2] cap strips can be particularly effective in reducing break out friction after long term storage.

- However, cap strips have the disadvantage of reduced sealing reliability in certain low pressure, low temperature applications.

- The use of backup rings to prevent extrusion in high pressure, high clearance, high temperature applications. However, the use of backup rings may cause excessive break out friction in certain pneumatic applications (Refer to Table 17 for examples of this problem in a typical missile application).

- The selective and controlled use of lubrication.

- Use of spring energized Teflon U-cups to overcome environments hostile to O-rings especially if dynamic break out friction is a problem.

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[1] The statement regarding highest durometer rating is based upon extensive testing in 1976 on low pressure seals for the Phoenix missile. The statement may seem controversial but has been found to be consistent with O-ring seal theory.

[2] Teflon is the DuPont trademark for fluorocarbon resins. In this document it refers to polytetrafluoroethylene, which is also known as TFE or, more properly, as PTFE.

2.6 Design Tips - Positive Considerations:

- Consider creating source control drawings to define O-ring requirements as well as the necessary quality controls. Drawings should include the following:

  (a) Where practical, the specification of standard sizes and tolerances per Aerospace Standard AS568, and where necessary, the use of non-standard sizes and/or tolerances.

  (b) Reference to the appropriate material specification. Additional requirements should be stated where necessary.

  (c) Approved vendor compound numbers. The approved compounds should be strictly limited to those that have demonstrated suitability during qualification test programs.

  (d) Inspection for flaws in accordance with MIL-STD-413 or Aerospace Standard AS871. The minimum inspection should be a 4.0 AQL, Level II, per MIL-STD-105. Consider 100% inspection for critical seal applications.

- Consider the use of PNF or fluorosilicone compounds for long term low pressure static seals or in short life low pressure dynamic seal applications especially at storage and operational temperatures below -25 °F. Refer to Appendix A for presentation of material properties.

- Specify O-rings with the largest standard cross-section and highest durometer rating permitted by space, material and assembly considerations (for reasons given in 2.5).

- Control the gland total eccentricity to a practical minimum for dynamic seals.

- Control cylindrical sealing bore taper to a practical minimum for reciprocating dynamic seals.

- Consider designing gland widths as narrow as practical when not covered by existing standards. However, the gland should accommodate the volume of the seal under maximum material and swell conditions.

- Face seal designs should provide sufficient structural rigidity to minimize opening of extrusion gaps during high pressure exposures. When weight is important, high pressure face seals may be a bad design choice unless parts are inherently stiff for other reasons.

- Where pressure dictates, use backup rings designed on a case by case evaluation of compatible material, assembly and environmental factors, especially in high temperature high diametrical clearance applications. Select one piece over split ring backups if assembly, dynamic friction and environmental factors allow.

- Consider incorporation of design features and processes which give margin against assembly damage.

2.6 (Continued):

- Provide for the most practical edge relief possible in holes, slots and other discontinuities which cannot be avoided and which O-rings must pass over during assembly or functional operation.

- Minimize the number of seals and the total linear length of seals in all component designs.

2.7 Design Tips - Negative Considerations:

- Avoid specifying O-rings by only standard specifications (i.e., MS etc.) in critical seal applications.

- Avoid the use of nitrile (Buna N) material for external static seals for long term storage or service especially if the application includes either of the following conditions:

  (a) Sealing pressures from zero to approximately 300 PSI while being subject to extreme cyclic changes in temperature (i.e. from below -25 °F to above +160 °F).

  (b) Functional operation at temperatures below -25 °F especially after long term cyclic temperature changes noted in condition (a) above.

- Avoid gland surface finishes greater than $32\sqrt{}$ or less than $4\sqrt{}$. In critical dynamic applications, avoid surface finishes greater than $16\sqrt{}$.

- Avoid designs that require excessive O-ring stretch (i.e., greater than 50%) during assembly.

- Avoid installed stretch exceeding 5% based on nominal O-ring dimensions.

- Avoid if possible, entrance angles greater than 15° half-angle measurement and entrance cone diameters less than the free outside diameter of the O-ring.

- Avoid gland designs in which the O-ring is required to seal more than one circumferential gap.

- Avoid if possible, designs that require the O-ring to slide over holes, slots or other discontinuities with sharp edges.

- Avoid if possible, non-circular face seal gland designs.

2.8 Detail O-Ring Gland Design:

2.8.1 General Description: Figure 1 and Tables 1 through 16 outline configuration and O-ring gland design information for various conditions encountered in missile hydraulic and pneumatic component designs. The information represents experience gained in the development of several missile systems; however, in certain areas, the information represents extrapolated data. It is anticipated that the information will facilitate more nearly optimum designs; however, design configurations should be proven by qualification testing as recommended in section 3.4.

2.8.2 Gland Design Criteria: The information contained in the tables presented in this section is similar to that in MIL-G-5514, with the primary differences as follows:

(a) The gland volumes are smaller. Some of the glands are as little as 7% greater than the O-ring volumes under maximum material conditions. If a volumetric swell greater than 7% is anticipated, the groove volume should be increased accordingly by increasing the width.

(b) The gland edge breaks are sharper in the high pressure applications.

(c) The squeeze is higher except in the dynamic pneumatic applications.

(d) The diametral clearance is tighter in high pressure applications without backup rings.

(e) The bore sizes for external seals generally conform to standard reamer sizes, for bores smaller than one inch.

(f) The shaft sizes for internal seals are such that upon the addition of a diametral clearance, the resulting dimension generally corresponds to a standard reamer size for bores smaller than one inch.

(g) The gland depth tolerances are generally tighter thru size 020.

(h) The allowable eccentricities are smaller in high pressure and/or dynamic applications.

(i) The sides of the grooves are perpendicular to the axis of the gland rather than being a maximum of 5° from perpendicular.

NOTE: Squeeze computations for the tables do not consider reduction in O-ring cross-section due to installed stretch.

2.8.3 Index of Figure and Tables:

FIGURE 1 - Conventional glands design applications are show in Figure 1.

TABLE 1 - Recommended bore and shaft dimensions.

TABLES 2 Thru 15 - Recommended gland dimensions, surface finishes, inspection levels and material hardnesses for various applications as follows:

TABLE 16 - Recommended bore sizes for using standard reamers.

A decision as to which section of Tables 2 thru 15 is appropriate will at times require a choice if an application encompasses:

(a) more than one set of conditions. In this case the designer should choose the smaller clearance and eccentricity, sharper corner break, smoother finish, and tighter inspection requirements.

(b) both the static and dynamic conditions. In this case the better choice will probably be the lesser squeeze shown for dynamic applications to minimize the spiraling and friction potential especially in reciprocating applications.

2.8.4 Drawing Diameter Calculation: The gland depths and diametral clearances shown in Figure 1 will not appear on engineering drawings, but are used to calculate certain diameters that will appear on the drawings as follows:

(a) For external seals:

- the rod/piston diameter C is calculated from dimension A per Table 1 and D per Tables 2 thru 15:

  C = A - D.

  The tolerance on C is the tolerance on D minus the tolerance on A. (See further for special cases.) As a check:

  D = A - C,

  where D must equal the value in Tables 2 thru 15, including the specified tolerances.

- The cylinder/bore diameter A is per Table 1.

- The gland root diameter F, is calculated from dimension A per Table 1 and L per Tables 2 thru 15:

  F = A - 2L.

  The tolerance on F is twice the tolerance on L, minus the tolerance on A. As a check:

  L = (A-F)/2,

  where L must equal the value in Tables 2 thru 15, including the specified tolerances.

- The groove width and other parameters are per Tables 2 thru 15.

(b) For internal seals:

- the rod/piston diameter B is per Table 1.

- The cylinder/bore diameter H, is calculated from dimension B per Table 1 and D per Tables 2 thru 15:

  H = B + D.

2.8.4 (Continued):

The tolerance on H is the tolerance on D minus the tolerance on B. (See further for special cases.) As a check:

D = H - B,

where D must equal the value in Tables 2 thru 15, including the specified tolerances.

- The gland diameter E, is calculated from dimension B per Table 1 and L from Tables 2 thru 15:

  E = B + 2L.

- The tolerance on E is twice the tolerance on L minus the tolerance on B. As a check:

  L = (E-B)/2,

  where L must equal the value in Tables 2 thru 15, including the specified tolerances.

- The groove width and other parameters are per Tables 2 thru 15.

(c) For face seals, internally pressurized:

- The outside diameter is dimension A per Table 1:

  O. D. = A.

- The inside diameter is calculated from dimension A per Table 1 and G from Table 14 or 15:

  I. D. = A - 2G.

- The tolerance on the I. D. is twice the tolerance on G minus the tolerance on A. As a check:

  G = (A-I.D.)/2,

  where G must equal the value in Tables 2 thru 15, including the specified tolerance.

- The groove depth and other parameters are per Table 14 or 15.

2.8.4 (Continued):

(d) For face seals, externally pressurized:

- the inside diameter is dimension B per Table 1:

  I. D. = B.

- The outside diameter is calculated from dimension B per Table 1 and G from Table 14 or 15:

  O. D. = B + 2G.

- The tolerance on the O. D. is twice the tolerance on G minus the tolerance on B. As a check:

  G = (O. D. -B)/2,

  where G must equal the value in Tables 2 thru 15, including the specified tolerance.

- The groove depth and other parameters are per Table 14 or 15.

In some cases, the tolerances that are specified for the diametral clearances D in Tables 2 thru 15 (i.e., for high pressure pneumatic applications, without backup rings) are equal to or tighter than the tolerances specified for the diameters A and B in Table 1. In these cases, the tolerances in Tables 2 thru 15 take precedence and, therefore, the tolerances for A or B must be reduced appropriately.

Example - Designing an internal seal of nominal size 013, for a low pressure dynamic hydraulic application would result in the following steps.

(a) The applicable dimensions would be:

$B = 0.435 \pm 0.0005$ per Table 1
$L = 0.055 \pm 0.0005$ per Table 2
$D = 0.004 \pm 0.003$ per Table 2

(b) The internal gland diameter is:

$$
\begin{aligned}
E &= B + 2L \\
&= (0.435 \pm 0.0005) + 2(0.055 \pm 0.0005) \\
&= (0.435 \pm 0.0005) + (0.110 \pm 0.001)
\end{aligned}
$$

Adding the basic dimensions and subtracting the B bore tolerance from the gland depth tolerance:

$E = 0.545 \pm 0.0005$ (ANSWER)

2.8.4 (Continued):

(c) The gland depth check is:

$$L = (E-B)/2$$
$$= [(0.545 \pm 0.0005) - (0.435 \pm 0.0005)]/2$$
$$= (0.110 \pm 0.001)/2$$
$$= 0.055 \pm 0.0005 \text{ (CHECK)}$$

(c) The rod bore is:

$$H = B + D$$
$$= (0.435 \pm 0.0005) + (0.004 \pm 0.003)$$

Adding the basic dimensions and subtracting the B bore tolerance from the diametral clearance tolerance:

$$= 0.439 \pm 0.0025 \text{ (ANSWER)}$$

(e) The Diametral Clearance Check is:

$$D = H-B$$
$$= (0.439 \pm 0.0025) - (0.435 \pm 0.0005)$$
$$= 0.004 \pm 0.003 \text{ (CHECK)}$$

2.8.5 Size and Stretch Considerations: Designs that require shaft or bore sizes different from those in the tables should consider the following factors.

(a) Shaft Size. Excessive O-ring stretch in the installed state should be avoided. Specifically, the shaft diameter (diameter B or F per Figure 1) should be within the following limits:

- Not more than 5% larger than the O-ring nominal I.D.
- Not smaller than the O-ring maximum I.D.

NOTE:

(1) These limits do not accommodate an infinite range of shaft sizes. Therefore, special O-rings and backup rings may be required.

(2) Little information is available regarding the effects of O-ring stretch beyond 5%, except that it contributes to the aging of nitriles particularly at elevated temperatures.

2.8.5 (Continued):

(3) If the designer employs stretch in excess of 5%, the following formula can be used to predict the resulting flattening of the O-ring:

$$y = 54\,[1 - (6/\sqrt{36 + x})]$$

where:

y = percent loss of compression diameter due to stretch (i.e., if y = 4, the reduction in the O-ring cross-section is 4%).
x = percent stretch on inside diameter (i.e., for 5% stretch, x = 5)

(4) The formula is empirical and represents published data with a maximum error of 0.3% for x = 0 to x = 26.

(b) Bore Size. To comply with good design practices, an effort should be made to use bore sizes that coincide with standard reamer sizes. This is sometimes awkward when designing internal seals where the bore diameter (H - per Figure 1) is determined by the rod diameter plus the clearance (B + D per Figure 1). The resulting dimension should be adjusted to coincide with a standard reamer size in the following cases:

- The bore size is less than one inch.
- The resulting O-ring stretch is compatible with the previously stated stretch limitations.
- The resulting dimensions are compatible with other design requirements.

NOTE: Standard reamer sizes are shown in Table 16.

EXAMPLE: Consider the following rationale:

(1) The bore diameter H of 0.439 ± 0.0025 derived in the previous example (i.e., paragraph 2.8.4) does not encompass one of the standard reamer sizes of Table 16.

(2) Using the previously stated limits (i.e., paragraph 2.8.5), the rod diameter B can vary between 0.431 (the O-ring maximum I.D.) and 0.447 (5% greater than the nominal I.D.) or:

B = 0.431/0.447
= 0.439 ± 0.008

(3) The bore diameter H, in this case is 0.004 ± 0.003 larger than B or:

H = (0.439 ± 0.008) + (0.004 ± 0.003)
= 0.443 ± 0.011

(4) The calculated bore diameter H thus encompasses either the 7/16 (0.4375) or the 29/64 (0.4531) reamer size. Since either size is satisfactory, assume that the more common size 7/16 (0.4375) is selected.

2.8.5 (Continued):

(5) The new size for the H bore diameter is 0.0015 smaller than the originally calculated diameter of 0.439. Therefore, each of the other two corresponding diameters are adjusted by the same amount and become:

B = 0.4335 ± 0.0005 (ANSWERS)
E = 0.5434 ± 0.0005

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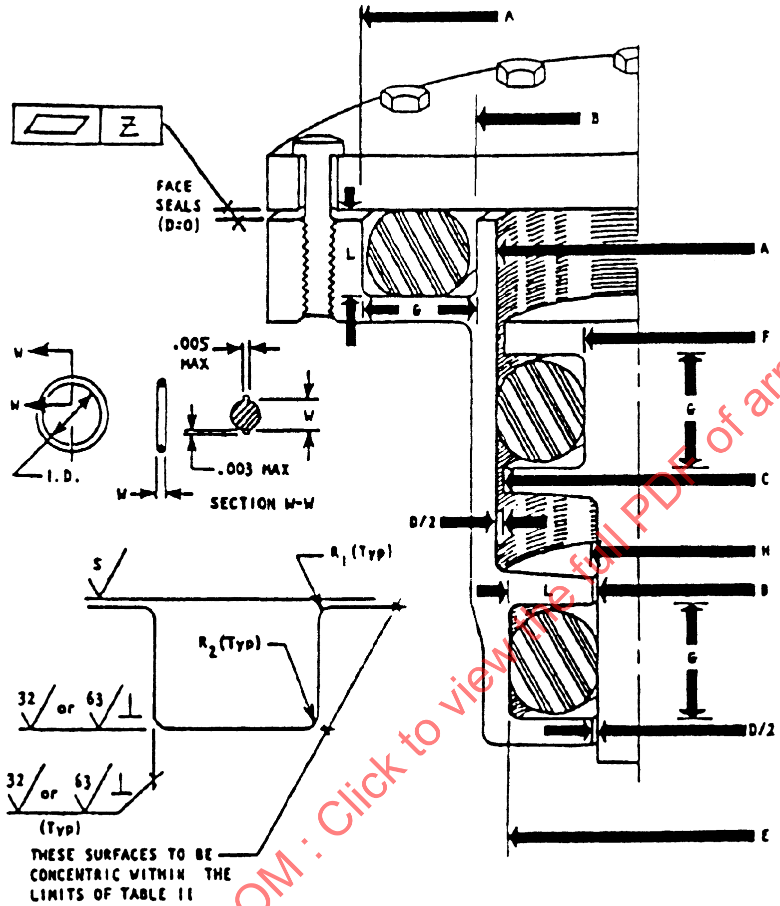

NOTES AND DEFINITIONS:

A - CYLINDER BORE I.D. PER TABLE I

B - ROD O.D. PER TABLE I.

C - PISTON O.D. = A - D.
D - DIAMETRAL CLEARANCE PER TABLE II.

E - INTERNAL GLAND I.D. = B + 2L.

F - PISTON GLAND O.D. = A - 2L.

G - GLAND WIDTH PER TABLE II.

H - ROD BORE I.D. = B + D
ID - O-RING I.D. PER TABLE I.
L - GLAND DEPTH PER TABLE II.
R_1 - CORNER BREAK RADIUS PER TABLE II.
R_2 - FILLET RADIUS PER TABLE II.
S - FINISH OF ADJACENT SURFACE PER TABLE II, AS DEFINED IN MIL-STD-10.

W - O-RING CROSS-SECTION DIAMETER PER TABLE I.

Z - SURFACE FLATNESS PER TABLE II-13 & II-14.

FIGURE 1 - Gland Design

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design

AS 568 Uniform Dash No.	Standard O-Ring Size				Bore Dia. External Seals		Rod Dia. Internal Seals		Notes-
	I.D.	±	W	±	A	±	B	±	
-004	0.070	0.005	0.070	0.003	0.185(0.189)	0.0005	0.074	0.0005	(a)(b)(c)
-005	0.101	0.005	0.070	0.003	0.213(0.221)		0.105		(a)(b)(c)
-006	0.114	0.005	0.070	0.003	0.228(0.2344)		0.123		(b)(c)
-007	0.145	0.005	0.070	0.003	0.261(0.2656)		0.152		(b)(c)
-008	0.176	0.005	0.070	0.003	0.295(0.2969)		0.183		(b)(c)
-009	0.208	0.005	0.070	0.003	0.323(0.3281)		0.217		(b)(c)
-010	0.239	0.005	0.070	0.003	0.358(0.3594)		0.248		(b)(c)
-011	0.301	0.005	0.070	0.003	0.4219		0.311		(b)
-012	0.364	0.005	0.070	0.003	0.4844		0.373		(b)
-013	0.426	0.005	0.070	0.003	0.552		0.435		(a)
-014	0.489	0.005	0.070	0.003	0.617		0.498		(a)
-015	0.551	0.007	0.070	0.003	0.6875		0.561		(a)
-016	0.614	0.009	0.070	0.003	0.750		0.623		(a)
-017	0.676	0.009	0.070	0.003	0.8125		0.686		(a)
-018	0.739	0.009	0.070	0.003	0.875		0.748		(a)
-019	0.801	0.009	0.070	0.003	0.9375		0.811		(a)
-020	0.864	0.009	0.070	0.003	1.000	0.0005	0.873	0.0005	(a)
-021	0.926	0.009	0.070	0.003	1.0625	0.001	0.935	0.001	(a)
-022	0.989	0.010	0.070	0.003	1.125		0.998		(a)
-023	1.051	0.010	0.070	0.003	1.1875		1.061		(a)
-024	1.114	0.010	0.070	0.003	1.250		1.123		(a)
-025	1.176	0.010	0.070	0.003	1.3125		1.186		(a)
-026	1.239	0.010	0.070	0.003	1.375		1.248		(a)
-027	1.301	0.010	0.070	0.003	1.4375		1.311		(a)
-028	1.364	0.013	0.070	0.003	1.500		1.373		(a)
-029	1.489	0.013	0.070	0.003	1.625		1.498		(a)
-030	1.614	0.013	0.070	0.003	1.750	0.001	1.623	0.001	(a)

NOTES:
(a) Not recommended for reciprocating applications.
(b) Sizes noted require considerable stretch when installed in standard external grooves and may require compounds with superior elongation, or two piece pistons.
(c) Use dimensions in parentheses for dynamic pneumatic applications.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size				Bore Dia. External Seals		Rod Dia. Internal Seals		Notes-
	I.D.	±	W	±	A	±	B	±	
-031	1.739	0.015	0.070	0.003	1.875	0.001	1.748	0.001	(a)
-032	1.864	0.015	0.070	0.003	2.000		1.873		(a)
-033	1.989	0.018	0.070	0.003	2.125		2.000		(a)
-034	2.114	0.018	0.070	0.003	2.250		2.125		(a)
-035	2.239	0.018	0.070	0.003	2.375		2.250		(a)
-036	2.364	0.018	0.070	0.003	2.500		2.375		(a)
-037	2.489	0.018	0.070	0.003	2.625		2.500		(a)
-038	2.614	0.020	0.070	0.003	2.750		2.625		(a)
-039	2.739	0.020	0.070	0.003	2.875		2.750		(a)
-040	2.864	0.024	0.070	0.003	3.000		2.875		(a)
-041	2.989	0.024	0.070	0.003	3.125		3.000		(a)
-042	3.239	0.024	0.070	0.003	3.375		3.250		(a)
-043	3.489	0.024	0.070	0.003	3.625		3.500		(a)
-044	3.739	0.027	0.070	0.003	3.875		3.750		(a)
-045	3.989	0.027	0.070	0.003	4.125		4.000		(a)
-046	4.239	0.030	0.070	0.003	4.375		4.250		(a)
-047	4.489	0.030	0.070	0.003	4.625		4.500		(a)
-048	4.739	0.030	0.070	0.003	4.875		4.750		(a)
-049	4.989	0.037	0.070	0.003	5.125		5.000		(a)
-050	5.239	0.037	0.070	0.003	5.375	0.001	5.250	0.001	(a)
-102	0.049	0.005	0.103	0.003	0.228	0.001	0.061	0.001	(b)
-103	0.081	0.005	0.103	0.003	0.257		0.092		(b)
-104	0.112	0.005	0.103	0.003	0.290		0.123		(b)
-105	0.143	0.005	0.103	0.003	0.323		0.155		(b)
-106	0.174	0.005	0.103	0.003	0.358		0.186		(b)
-107	0.206	0.005	0.103	0.003	0.3906		0.217		(b)
-108	0.237	0.005	0.103	0.003	0.4219		0.248		(b)
-109	0.299	0.005	0.103	0.003	0.4844		0.311		(b)
-110	0.362	0.005	0.103	0.003	0.5625	0.001	0.373	0.001	(b)

NOTES: (a) Not recommended for reciprocating applications.
(b) Sizes noted require considerable stretch when installed in standard external grooves and may require compounds with superior elongation, or two piece pistons.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size I.D.	±	W	±	Bore Dia. External Seals A	±	Rod Dia. Internal Seals B	±	Notes-
-111	0.424	0.005	0.103	0.003	0.625	0.001	0.436	0.001	(b)
-112	0.487	0.005	0.103	0.003	0.6875		0.498		(b)
-113	0.549	0.007	0.103	0.003	0.750		0.561		(b)
-114	0.612	0.009	0.103	0.003	0.8125		0.623		
-115	0.674	0.009	0.103	0.003	0.875		0.686		
-116	0.737	0.009	0.103	0.003	0.9375		0.748		
-117	0.799	0.010	0.103	0.003	1.000		0.811		(a)
-118	0.862	0.010	0.103	0.003	1.0625		0.873		(a)
-119	0.924	0.010	0.103	0.003	1.125		0.936		(a)
-120	0.987	0.010	0.103	0.003	1.1875		0.998		(a)
-121	1.049	0.010	0.103	0.003	1.250		1.061		(a)
-122	1.112	0.010	0.103	0.003	1.3125		1.123		(a)
-123	1.174	0.012	0.103	0.003	1.375		1.186		(a)
-124	1.237	0.012	0.103	0.003	1.4375		1.248		(a)
-125	1.299	0.012	0.103	0.003	1.500		1.311		(a)
-126	1.362	0.012	0.103	0.003	1.5625		1.373		(a)
-127	1.424	0.012	0.103	0.003	1.625		1.436		(a)
-128	1.487	0.012	0.103	0.003	1.6875		1.498		(a)
-129	1.549	0.015	0.103	0.003	1.750		1.561		(a)
-130	1.612	0.015	0.103	0.003	1.8125		1.623		(a)
-131	1.674	0.015	0.103	0.003	1.875		1.686		(a)
-132	1.737	0.015	0.103	0.003	1.9375		1.748		(a)
-133	1.799	0.015	0.103	0.003	2.000		1.811		(a)
-134	1.862	0.015	0.103	0.003	2.0625		1.873		(a)
-135	1.925	0.017	0.103	0.003	2.125		1.936		(a)
-136	1.987	0.017	0.103	0.003	2.1875		2.000		(a)
-137	2.050	0.017	0.103	0.003	2.250		2.0625		(a)
-138	2.112	0.017	0.103	0.003	2.3125		2.125		(a)
-139	2.175	0.017	0.103	0.003	2.375		2.1875		(a)
-140	2.237	0.017	0.103	0.003	2.4375	0.001	2.250	0.001	(a)

NOTES: (a) Not recommended for reciprocating applications.
(b) Sizes noted require considerable stretch when installed in standard external grooves and may require compounds with superior elongation, or two piece pistons.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size I.D.	±	W	±	Bore Dia. External Seals A	±	Rod Dia. Internal Seals B	±	Notes-
-141	2.300	0.020	0.103	0.003	2.500	0.001	2.3125	0.001	(a)
-142	2.362	0.020	0.103	0.003	2.5625		2.375		(a)
-143	2.425	0.020	0.103	0.003	2.625		2.4375		(a)
-144	2.487	0.020	0.103	0.003	2.6875		2.500		(a)
-145	2.550	0.020	0.103	0.003	2.750		2.5625		(a)
-146	2.612	0.020	0.103	0.003	2.8125		2.625		(a)
-147	2.675	0.022	0.103	0.003	2.875		2.6875		(a)
-148	2.737	0.022	0.103	0.003	2.9375		2.750		(a)
-149	2.800	0.022	0.103	0.003	3.000		2.8125		(a)
-150	2.862	0.022	0.103	0.003	3.0625		2.875		(a)
-151	2.987	0.024	0.103	0.003	3.250		3.000		(a)
-152	3.237	0.024	0.103	0.003	3.500		3.250		(a)
-153	3.487	0.024	0.103	0.003	3.750		3.500		(a)
-154	3.737	0.028	0.103	0.003	4.000		3.750		(a)
-155	3.987	0.028	0.103	0.003	4.250		4.000		(a)
-156	4.237	0.030	0.103	0.003	4.500		4.250		(a)
-157	4.487	0.030	0.103	0.003	4.750		4.500		(a)
-158	4.737	0.030	0.103	0.003	5.000		4.750		(a)
-159	4.987	0.035	0.103	0.003	5.250		5.000		(a)
-160	5.237	0.035	0.103	0.003	5.500		5.250		(a)
-161	5.487	0.035	0.103	0.003	5.750		5.500		(a)
-162	5.737	0.035	0.103	0.003	6.000		5.750		(a)
-163	5.987	0.035	0.103	0.003	6.250		6.000		(a)
-164	6.237	0.040	0.103	0.003	6.500		6.250		(a)
-165	6.487	0.040	0.103	0.003	6.750		6.500		(a)
-166	6.737	0.040	0.103	0.003	7.000		6.750		(a)
-167	6.987	0.040	0.103	0.003	7.250		7.000		(a)
-168	7.237	0.045	0.103	0.003	7.500		7.250		(a)
-169	7.487	0.045	0.103	0.003	7.750		7.500		(a)
-170	7.737	0.045	0.103	0.003	8.000	0.001	7.750	0.001	(a)

NOTES: (a) Not recommended for reciprocating applications.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size I.D.	±	W	±	Bore Dia. External Seals A	±	Rod Dia. Internal Seals B	±	Notes-
-171	7.987	0.045	0.103	0.003	8.250	0.001	8.000	0.001	(a)
-172	8.237	0.050	0.103	0.003	8.500		8.250		(a)
-173	8.487	0.050	0.103	0.003	8.750		8.500		(a)
-174	8.737	0.050	0.103	0.003	9.000		8.750		(a)
-175	8.987	0.050	0.103	0.003	9.250		9.000		(a)
-176	9.237	0.055	0.103	0.003	9.500		9.250		(a)
-177	9.487	0.055	0.103	0.003	9.750		9.500		(a)
-178	9.737	0.055	0.103	0.003	10.000	0.001	9.750	0.001	(a)
-201	0.171	0.005	0.139	0.004	0.4375	0.001	0.182	0.001	(b)
-202	0.234	0.005	0.139	0.004	0.500		0.248		(b)
-203	0.296	0.005	0.139	0.004	0.5625		0.311		(b)
-204	0.359	0.005	0.139	0.004	0.625		0.373		
-205	0.421	0.005	0.139	0.004	0.6875		0.436		
-206	0.484	0.005	0.139	0.004	0.750		0.498		
-207	0.546	0.007	0.139	0.004	0.8125		0.561		
-208	0.609	0.009	0.139	0.004	0.875		0.623		
-209	0.671	0.009	0.139	0.004	0.9375		0.686		
-210	0.734	0.010	0.139	0.004	1.000		0.748		
-211	0.796	0.010	0.139	0.004	1.0625		0.811		
-212	0.859	0.010	0.139	0.004	1.125		0.873		
-213	0.921	0.010	0.139	0.004	1.1875		0.936		
-214	0.984	0.010	0.139	0.004	1.250		0.998		
-215	1.046	0.010	0.139	0.004	1.3125		1.061		
-216	1.109	0.012	0.139	0.004	1.375		1.123		
-217	1.171	0.012	0.139	0.004	1.4375		1.186		
-218	1.234	0.012	0.139	0.004	1.500		1.248		
-219	1.296	0.012	0.139	0.004	1.5625		1.311		
-220	1.359	0.012	0.139	0.004	1.625	0.001	1.373	0.001	

NOTES: (a) Not recommended for reciprocating applications.
(b) Sizes noted require considerable stretch when installed in standard external grooves and may require compounds with superior elongation, or two piece pistons.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size				Bore Dia. External Seals		Rod Dia. Internal Seals		Notes-
	I.D.	±	W	±	A	±	B	±	
-221	1.421	0.012	0.139	0.004	1.6875	0.001	1.436	0.001	
-222	1.484	0.015	0.139	0.004	1.750		1.498		
-223	1.609	0.015	0.139	0.004	1.875		1.623		(a)
-224	1.734	0.015	0.139	0.004	2.000		1.748		(a)
-225	1.859	0.018	0.139	0.004	2.125		1.873		(a)
-226	1.984	0.018	0.139	0.004	2.250		2.000		(a)
-227	2.109	0.018	0.139	0.004	2.375		2.125		(a)
-228	2.234	0.020	0.139	0.004	2.500		2.250		(a)
-229	2.359	0.020	0.139	0.004	2.625		2.375		(a)
-230	2.484	0.020	0.139	0.004	2.750		2.500		(a)
-231	2.609	0.020	0.139	0.004	2.875		2.625		(a)
-232	2.734	0.024	0.139	0.004	3.000		2.750		(a)
-233	2.859	0.024	0.139	0.004	3.125		2.875		(a)
-234	2.984	0.024	0.139	0.004	3.250		3.000		(a)
-235	3.109	0.024	0.139	0.004	3.375		3.125		(a)
-236	3.234	0.024	0.139	0.004	3.500		3.250		(a)
-237	3.359	0.024	0.139	0.004	3.625		3.375		(a)
-238	3.484	0.024	0.139	0.004	3.750		3.500		(a)
-239	3.609	0.028	0.139	0.004	3.875		3.625		(a)
-240	3.734	0.028	0.139	0.004	4.000		3.750		(a)
-241	3.859	0.028	0.139	0.004	4.125		3.875		(a)
-242	3.984	0.028	0.139	0.004	4.250		4.000		(a)
-243	4.109	0.028	0.139	0.004	4.375		4.125		(a)
-244	4.234	0.030	0.139	0.004	4.500		4.250		(a)
-245	4.359	0.030	0.139	0.004	4.625		4.375		(a)
-246	4.484	0.030	0.139	0.004	4.750		4.500		(a)
-247	4.609	0.030	0.139	0.004	4.875		4.625		(a)
-248	4.734	0.030	0.139	0.004	5.000		4.750		(a)
-249	4.859	0.035	0.139	0.004	5.125		4.875		(a)
-250	4.984	0.035	0.139	0.004	5.250	0.001	5.000	0.001	(a)

NOTES: (a) Not recommended for reciprocating applications.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size I.D.	±	W	±	Bore Dia. External Seals A	±	Rod Dia. Internal Seals B	±	Notes-
-251	5.109	0.035	0.139	0.004	5.375	0.001	5.125	0.001	(a)
-252	5.234	0.035	0.139	0.004	5.500		5.250		(a)
-253	5.359	0.035	0.139	0.004	5.625		5.375		(a)
-254	5.484	0.035	0.139	0.004	5.750		5.500		(a)
-255	5.609	0.035	0.139	0.004	5.875		5.625		(a)
-256	5.734	0.035	0.139	0.004	6.000		5.750		(a)
-257	5.859	0.035	0.139	0.004	6.125		5.875		(a)
-258	5.984	0.035	0.139	0.004	6.250		6.000		(a)
-259	6.234	0.040	0.139	0.004	6.500		6.250		(a)
-260	6.484	0.040	0.139	0.004	6.750		6.500		(a)
-261	6.734	0.040	0.139	0.004	7.000		6.750		(a)
-262	6.984	0.040	0.139	0.004	7.250		7.000		(a)
-263	7.234	0.045	0.139	0.004	7.500		7.250		(a)
-264	7.484	0.045	0.139	0.004	7.750		7.500		(a)
-265	7.734	0.045	0.139	0.004	8.000		7.750		(a)
-266	7.984	0.045	0.139	0.004	8.250		8.000		(a)
-267	8.234	0.050	0.139	0.004	8.500		8.250		(a)
-268	8.484	0.050	0.139	0.004	8.750		8.500		(a)
-269	8.734	0.050	0.139	0.004	9.000		8.750		(a)
-270	8.984	0.050	0.139	0.004	9.250		9.000		(a)
-271	9.234	0.055	0.139	0.004	9.500		9.250		(a)
-272	9.484	0.055	0.139	0.004	9.750		9.500		(a)
-273	9.734	0.055	0.139	0.004	10.000		9.750		(a)
-274	9.984	0.055	0.139	0.004	10.250		10.000		(a)
-275	10.484	0.055	0.139	0.004	10.750		10.500		(a)
-276	10.984	0.065	0.139	0.004	11.250		11.000		(a)
-277	11.484	0.065	0.139	0.004	11.750		11.500		(a)
-278	11.984	0.065	0.139	0.004	12.250		12.000		(a)
-279	12.984	0.065	0.139	0.004	13.250		13.000		(a)
-280	13.984	0.065	0.139	0.004	14.250	0.001	14.000	0.001	(a)

NOTES: (a) Not recommended for reciprocating applications.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size				Bore Dia. External Seals		Rod Dia. Internal Seals		Notes-
	I.D.	±	W	±	A	±	B	±	
-281	14.984	0.065	0.139	0.004	15.250	0.001	15.000	0.001	(a)
-282	15.955	0.075	0.139	0.004	16.250		16.000		(a)
-283	16.955	0.080	0.139	0.004	17.250		17.000		(a)
-284	17.955	0.085	0.139	0.004	18.250	0.001	18.000	0.001	(a)
-309	0.412	0.005	0.210	0.005	0.8125	0.001	0.436	0.001	
-310	0.475	0.005	0.210	0.005	0.875		0.498		
-311	0.537	0.007	0.210	0.005	0.9375		0.560		
-312	0.600	0.009	0.210	0.005	1.000		0.623		
-313	0.662	0.009	0.210	0.005	1.0625		0.686		
-314	0.725	0.010	0.210	0.005	1.125		0.748		
-315	0.787	0.010	0.210	0.005	1.1875		0.811		
-316	0.850	0.010	0.210	0.005	1.250		0.873		
-317	0.912	0.010	0.210	0.005	1.3125		0.936		
-318	0.975	0.010	0.210	0.005	1.375		0.998		
-319	1.037	0.010	0.210	0.005	1.4375		1.061		
-320	1.100	0.012	0.210	0.005	1.500		1.123		
-321	1.162	0.012	0.210	0.005	1.5625		1.186		
-322	1.225	0.012	0.210	0.005	1.625		1.248		
-323	1.287	0.012	0.210	0.005	1.6875		1.311		
-324	1.350	0.012	0.210	0.005	1.750		1.373		
-325	1.475	0.015	0.210	0.005	1.875		1.498		
-326	1.600	0.015	0.210	0.005	2.000		1.623		
-327	1.725	0.015	0.210	0.005	2.125		1.748		
-328	1.850	0.015	0.210	0.005	2.250		1.873		
-329	1.975	0.018	0.210	0.005	2.375		2.000		
-330	2.100	0.018	0.210	0.005	2.500		2.125		
-331	2.225	0.018	0.210	0.005	2.625		2.250		
-332	2.350	0.018	0.210	0.005	2.750		2.375		
-333	2.475	0.020	0.210	0.005	2.875		2.500		
-334	2.600	0.020	0.210	0.005	3.000		2.625		
-335	2.725	0.020	0.210	0.005	3.125	0.001	2.750	0.001	

NOTES: (a) Not recommended for reciprocating applications.

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size I.D.	±	W	±	Bore Dia. External Seals A	±	Rod Dia. Internal Seals B	±	Notes-
-336	2.850	0.020	0.210	0.005	3.250	0.001	2.875	0.001	
-337	2.975	0.024	0.210	0.005	3.375		3.000		
-338	3.100	0.024	0.210	0.005	3.500		3.125		
-339	3.225	0.024	0.210	0.005	3.625		3.250		
-340	3.350	0.024	0.210	0.005	3.750		3.375		
-341	3.475	0.024	0.210	0.005	3.875		3.500		
-342	3.600	0.028	0.210	0.005	4.000		3.625		
-343	3.725	0.028	0.210	0.005	4.125		3.750		
-344	3.850	0.028	0.210	0.005	4.250		3.875		
-345	3.975	0.028	0.210	0.005	4.375		4.000		
-346	4.100	0.028	0.210	0.005	4.500		4.125		
-347	4.225	0.030	0.210	0.005	4.625		4.250		
-348	4.350	0.030	0.210	0.005	4.750		4.375		
-349	4.475	0.030	0.210	0.005	4.875		4.500		
-350	4.600	0.030	0.210	0.005	5.000		4.625		
-351	4.725	0.030	0.210	0.005	5.125		4.750		
-352	4.850	0.030	0.210	0.005	5.250		4.875		
-353	4.975	0.037	0.210	0.005	5.375		5.000		
-354	5.100	0.037	0.210	0.005	5.500		5.125		
-355	5.225	0.037	0.210	0.005	5.625		5.250		
-356	5.350	0.037	0.210	0.005	5.750		5.375		
-357	5.475	0.037	0.210	0.005	5.875		5.500		
-358	5.600	0.037	0.210	0.005	6.000		5.625		
-359	5.725	0.037	0.210	0.005	6.125		5.750		
-360	5.850	0.037	0.210	0.005	6.250		5.875		
-361	5.975	0.037	0.210	0.005	6.375		6.000		
-362	6.225	0.040	0.210	0.005	6.625		6.250		
-363	6.475	0.040	0.210	0.005	6.875		6.500		
-364	6.725	0.040	0.210	0.005	7.125		6.750		
-365	6.975	0.040	0.210	0.005	7.375	0.001	7.000	0.001	

TABLE 1 - Bore and Rod Dimensions for O-Ring Gland Seal Design (Continued)

AS 568 Uniform Dash No.	Standard O-Ring Size				Bore Dia. External Seals		Rod Dia. Internal Seals		Notes-
	I.D.	±	W	±	A	±	B	±	
-366	7.225	0.045	0.210	0.005	7.625	0.001	7.250	0.001	
-367	7.475	0.045	0.210	0.005	7.875		7.500		
-368	7.725	0.045	0.210	0.005	8.125		7.750		
-369	7.975	0.045	0.210	0.005	8.375		8.000		
-370	8.225	0.050	0.210	0.005	8.625		8.250		
-371	8.475	0.050	0.210	0.005	8.875		8.500		
-372	8.725	0.050	0.210	0.005	9.125		8.750		
-373	8.975	0.050	0.210	0.005	9.375		9.000		
-374	9.225	0.055	0.210	0.005	9.625		9.250		
-375	9.475	0.055	0.210	0.005	9.875		9.500		
-376	9.725	0.055	0.210	0.005	10.125		9.750		
-377	9.975	0.055	0.210	0.005	10.375		10.000		
-378	10.475	0.060	0.210	0.005	10.875		10.500		
-379	10.975	0.060	0.210	0.005	11.375		11.000		
-380	11.475	0.065	0.210	0.005	11.875		11.500		
-381	11.975	0.065	0.210	0.005	12.375		12.000		
-382	12.975	0.065	0.210	0.005	13.375		13.000		
-383	13.975	0.070	0.210	0.005	14.375		14.000		
-384	14.975	0.070	0.210	0.005	15.375		15.000		
-385	15.955	0.075	0.210	0.005	16.375		16.000		
-386	16.955	0.080	0.210	0.005	17.375		17.000		
-387	17.955	0.085	0.210	0.005	18.375		18.000		
-388	18.953	0.090	0.210	0.005	19.375		19.000		
-389	19.953	0.095	0.210	0.005	20.375		20.000		
-390	20.953	0.095	0.210	0.005	21.375		21.000		
-391	21.953	0.100	0.210	0.005	22.375		22.000		
-392	22.940	0.105	0.210	0.005	23.375		23.000		
-393	23.940	0.110	0.210	0.005	24.375		24.000		
-394	24.940	0.115	0.210	0.005	25.375		25.000		
-395	25.940	0.120	0.210	0.005	26.375	0.001	26.000	0.001	

TABLE 2 - O-Ring Gland Dimensions for Low Pressure, Dynamic Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width			D Diam Clearance		Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze		Percent Squeeze		S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
			No Back-up	One Back-up	Two Back-ups	No Back-up	With Back-up				Max.	Min.	Max.	Min.			
004 thru 020	0.070 ±0.003	0.055 ±0.0005	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.006 +0.003	0.006 +0.003	0.001 Max	0.008 ±0.002	0.010 ±0.005	0.0185	0.0115	25.3	17.2	16√	100%	70 ±5
021 thru 050	0.070 ±0.003	0.055 +0.001	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.006 +0.003	0.006 +0.003	0.001 Max	0.008 +0.002	0.010 ±0.005	0.019	0.011	26.0	16.4	16√	100%	70 ±5
102 thru 178	0.103 ±0.003	0.085 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.007 +0.003	0.007 +0.003	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.022	0.014	20.8	14.0	16√	100%	70 ±5
201 thru 284	0.139 ±0.004	0.118 ±0.001	0.160 ±0.005	0.210 ±0.005	0.260 ±0.005	0.008 +0.004	0.008 +0.004	0.003 Max	0.008 ±0.002	0.015 ±0.005	0.026	0.016	18.2	11.9	16√	100%	70 ±5
309 thru 395	0.210 ±0.005	0.185 ±0.001	0.230 ±0.005	0.280 ±0.005	0.330 ±0.005	0.009 +0.005	0.009 +0.005	0.004 Max	0.008 ±0.002	0.025 ±0.005	0.031	0.019	14.4	9.3	16√	100%	70 ±5

NOTES: (A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 3 - O-Ring Gland Dimensions for Medium Pressure, Dynamic Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width			D Diam Clearance		Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze		Percent Squeeze		S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
			No Back-up	One Back-up	Two Back-ups	No Back-up	With Back-up				Max.	Min.	Max.	Min.			
004 thru 020	0.070 ±0.003	0.055 ±0.0005	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.002 +0.001	0.004 ±0.002	0.001 Max	0.008 ±0.002	0.010 ±0.005	0.0185	0.0115	25.3	17.2	32	4.0	70 ±5
021 thru 050	0.070 ±0.003	0.055 ±0.001	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.002 ±0.001	0.004 ±0.002	0.001 Max	0.008 ±0.002	0.010 ±0.005	0.019	0.011	26.0	16.4	32	4.0	70 ±5
102 thru 178	0.103 +0.003	0.086 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.003 ±0.002	0.005 ±0.002	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.021	0.013	19.8	13.0	32	4.0	70 ±5
201 thru 284	0.139 ±0.004	0.120 ±0.001	0.160 ±0.005	0.210 ±0.005	0.260 ±0.005	0.004 ±0.003	0.006 ±0.003	0.003 Max	0.008 ±0.002	0.015 ±0.005	0.024	0.014	16.8	10.4	32	4.0	70 ±5
309 thru 395	0.210 ±0.005	0.186 ±0.001	0.230 ±0.005	0.280 ±0.005	0.330 ±0.005	0.005 ±0.003	0.007 ±0.004	0.004 Max	0.008 ±0.002	0.025 ±0.005	0.030	0.018	14.0	8.8	32	4.0	70 ±5

NOTES: (A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 4 - O-Ring Gland Dimensions for High Pressure, Dynamic Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width: No Back-up	G Gland Width: One Back-up	G Gland Width: Two Back-ups	D Diam Clearance: No Back-up	D Diam Clearance: With Back-up	Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze: Max.	Squeeze: Min.	Percent Squeeze: Max.	Percent Squeeze: Min.	S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
004 thru 020	0.070 ±0.003	0.056 ±0.0005	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.0015 ±0.001	0.002 ±0.001	0.001 Max	0.001 Max	0.010 ±0.005	0.0175	0.0105	24.0	15.7	32 √	4.0	70 ±5
021 thru 050	0.070 ±0.003	0.056 ±0.001	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.0015 ±0.001	0.002 ±0.001	0.001 Max	0.001 Max	0.010 ±0.005	0.018	0.010	24.7	14.9	32 √	4.0	70 ±5
102 thru 178	0.103 ±0.003	0.088 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.002 ±0.001	0.003 ±0.002	0.002 Max	0.002 Max	0.010 ±0.005	0.019	0.011	17.9	11.0	32 √	4.0	70 ±5
201 thru 284	0.139 ±0.004	0.122 ±0.001	0.160 ±0.005	0.210 ±0.005	0.260 ±0.005	0.003 ±0.002	0.004 ±0.002	0.003 Max	0.003 Max	0.015 ±0.005	0.022	0.012	15.4	8.9	32 √	4.0	70 ±5
309 thru 395	0.210 ±0.005	0.187 ±0.001	0.230 ±0.005	0.280 ±0.005	0.330 ±0.005	0.004 ±0.002	0.005 ±0.002	0.004 Max	0.005 Max	0.025 ±0.005	0.029	0.017	13.5	8.3	32 √	4.0	70 ±5

NOTES:

(A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 5 - O-Ring Gland Dimensions for Low Pressure, Static Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width			D Diam Clearance		Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze		Percent Squeeze		S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
			No Back-up	One Back-up	Two Back-ups	No Back-up	With Back-up				Max.	Min.	Max.	Min.			
004 thru 020	0.070 ±0.003	0.055 ±0.0005	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.004 ±0.003	0.005 -0.003	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.0185	0.0115	25.3	17.2	16√	1.5	70 ±5
021 thru 050	0.070 ±0.003	0.055 ±0.001	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.004 ±0.003	0.005 0.003	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.019	0.011	26.0	16.4	16√	1.5	70 ±5
102 thru 178	0.103 ±0.003	0.084 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.005 ±0.003	0.006 ±0.003	0.004 Max	0.008 ±0.002	0.010 ±0.005	0.023	0.015	21.7	15.0	16√	1.5	70 ±5
201 thru 284	0.139 ±0.004	0.113 ±0.001	0.162 ±0.005	0.212 ±0.005	0.262 ±0.005	0.006 ±0.004	0.007 ±0.004	0.005 Max	0.008 ±0.002	0.015 ±0.005	0.031	0.021	21.7	15.6	16√	1.5	70 ±5
309 thru 395	0.210 ±0.005	0.171 ±0.001	0.240 ±0.005	0.290 ±0.005	0.340 ±0.005	0.007 ±0.005	0.008 ±0.005	0.006 Max	0.008 ±0.002	0.025 ±0.005	0.045	0.029	20.9	14.1	16√	1.5	70 ±5

NOTES: (A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 6 - O-Ring Gland Dimensions for Medium Pressure, Static Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width: No Back-up	G Gland Width: One Back-up	G Gland Width: Two Back-ups	D Diam Clearance: No Back-up	D Diam Clearance: With Back-up	Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze: Max.	Squeeze: Min.	Percent Squeeze: Max.	Percent Squeeze: Min.	S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
004 thru 020	0.070 ±0.003	0.055 ±0.0005	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.002 ±0.001	0.004 ±0.002	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.0185	0.0115	25.3	17.2	32 √	4.0	70 ±5
021 thru 050	0.070 ±0.003	0.055 ±0.001	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.002 ±0.001	0.004 ±0.002	0.002 Max	0.008 ±0.002	0.010 ±0.005	0.019	0.011	26.0	16.4	32 √	4.0	70 ±5
102 thru 178	0.103 ±0.003	0.084 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.003 ±0.002	0.005 ±0.002	0.004 Max	0.008 ±0.002	0.010 ±0.005	0.023	0.015	21.7	15.0	32 √	4.0	70 ±5
201 thru 284	0.139 ±0.004	0.113 ±0.001	0.162 ±0.005	0.212 ±0.005	0.262 ±0.005	0.004 ±0.003	0.006 ±0.003	0.005 Max	0.008 ±0.002	0.015 ±0.005	0.031	0.021	21.7	15.6	32 √	4.0	70 ±5
309 thru 395	0.210 ±0.005	0.171 ±0.001	0.240 ±0.005	0.290 ±0.005	0.340 ±0.005	0.005 ±0.003	0.007 ±0.004	0.006 Max	0.008 ±0.002	0.025 ±0.005	0.045	0.029	20.9	14.1	32 √	4.0	70 ±5

NOTES:

(A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 7 - O-Ring Gland Dimensions for High Pressure, Static Hydraulic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width			D Diam Clearance		Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze		Percent Squeeze		S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
			No Back-up	One Back-up	Two Back-ups	No Back-up	With Back-up				Max.	Min.	Max.	Min.			
004 thru 020	0.070 ±0.003	0.055 ±0.0005	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.002 ±0.001	0.003 ±0.001	0.001 Max	0.001 Max	0.010 ±0.005	0.0185	0.0115	25.3	17.2	32	4.0	70 ±5
021 thru 050	0.070 ±0.003	0.055 ±0.001	0.088 ±0.005	0.138 ±0.005	0.188 ±0.005	0.002 ±0.001	0.003 ±0.001	0.001 Max	0.001 Max	0.010 ±0.005	0.019	0.011	26.0	16.4	32	4.0	70 ±5
102 thru 178	0.103 ±0.003	0.084 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.003 ±0.001	0.004 ±0.002	0.002 Max	0.002 Max	0.010 ±0.005	0.023	0.015	21.7	15.0	32	4.0	70 ±5
201 thru 284	0.139 ±0.004	0.113 ±0.001	0.162 ±0.005	0.212 ±0.005	0.262 ±0.005	0.004 ±0.002	0.005 ±0.002	0.003 Max	0.003 Max	0.015 ±0.005	0.031	0.021	21.7	15.6	32	4.0	70 ±5
309 thru 395	0.210 ±0.005	0.171 ±0.001	0.240 ±0.005	0.290 ±0.005	0.340 ±0.005	0.005 ±0.002	0.006 ±0.002	0.004 Max	0.005 Max	0.025 ±0.005	0.045	0.029	20.9	14.1	32	4.0	70 ±5

NOTES: (A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 8 - O-Ring Gland Dimensions for Low Pressure, Dynamic Pneumatic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width: No Back-up	G Gland Width: One Back-up	G Gland Width: Two Back-ups	D Diam Clearance: No Back-up	D Diam Clearance: With Back-up	Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze: Max.	Squeeze: Min.	Percent Squeeze: Max.	Percent Squeeze: Min.	S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
004 thru 020	0.070 ±0.003	0.057 ±0.0005	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.0015 ±0.0005	0.004 ±0.002	0.0005 Max	0.008 ±0.002	0.010 ±0.005	0.0165	0.0095	22.6	14.2	32 ✓	4.0	70 ±5
021 thru 050	0.070 ±0.003	0.057 ±0.001	0.090 ±0.005	0.140 ±0.005	0.190 ±0.005	0.0015 ±0.0005	0.004 ±0.002	0.001 Max	0.008 ±0.002	0.010 ±0.005	0.017	0.009	23.3	13.4	32 ✓	4.0	70 ±5
102 thru 178	0.103 ±0.003	0.086 ±0.001	0.120 ±0.005	0.170 ±0.005	0.220 ±0.005	0.002 ±0.001	0.005 ±0.003	0.001 Max	0.008 ±0.002	0.010 ±0.005	0.021	0.013	19.8	13.0	32 ✓	4.0	70 ±5
201 thru 284	0.139 ±0.004	0.119 ±0.001	0.160 ±0.005	0.210 ±0.005	0.260 ±0.005	0.004 ±0.002	0.006 ±0.004	0.002 Max	0.008 ±0.002	0.015 ±0.005	0.025	0.015	17.5	11.1	32 ✓	4.0	70 ±5
309 thru 395	0.210 ±0.005	0.185 ±0.001	0.230 ±0.005	0.280 ±0.005	0.380 ±0.005	0.006 ±0.003	0.007 ±0.005	0.003 Max	0.008 ±0.002	0.025 ±0.005	0.031	0.019	14.4	9.3	32 ✓	4.0	70 ±5

NOTES:
(A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.
(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.

TABLE 9 - O-Ring Gland Dimensions for Medium Pressure, Dynamic Pneumatic Applications

AS 568 Uniform Dash No.	W Cross Section	L Gland Depth	G Gland Width: No Back-up	G Gland Width: One Back-up	G Gland Width: Two Back-ups	D Diam Clearance: No Back-up	D Diam Clearance: With Back-up	Eccentricity	R_1 Edge Break	R_2 Fillet Radius	Squeeze: Max.	Squeeze: Min.	Percent Squeeze: Max.	Percent Squeeze: Min.	S Surface Finish	AQL Note (A) (B)	Hardness Shore A Durometer
004 thru 020	0.070	0.057	0.090	0.140	0.190	0.001	0.004	0.0004	0.008	0.010	0.0165	0.0095	22.6	14.2	32 √	4.0	70 ±5
	±0.003	±0.0005	-0.005	±0.005	±0.005	±0.0004	±0.002	Max	±0.002	±0.005							
021 thru 050	0.070	0.057	0.090	0.140	0.190	0.001	0.004	0.0008	0.008	0.010	0.017	0.009	23.3	13.4	32 √	4.0	70 ±5
	±0.003	±0.001	±0.005	±0.005	±0.005	±0.0004	±0.002	Max	±0.002	±0.005							
102 thru 178	0.103	0.086	0.120	0.170	0.220	0.002	0.005	0.001	0.008	0.010	0.021	0.013	19.8	13.0	32 √	4.0	70 ±5
	±0.003	±0.001	±0.005	±0.005	±0.005	±0.001	±0.002	Max	±0.002	±0.005							
201 thru 284	0.139	0.119	0.160	0.210	0.260	0.003	0.006	0.002	0.008	0.015	0.025	0.015	17.5	11.1	32 √	4.0	70 ±5
	±0.004	±0.001	±0.005	±0.005	±0.005	±0.002	±0.003	Max	±0.002	±0.005							
309 thru 395	0.210	0.185	0.230	0.280	0.380	0.004	0.007	0.003	0.008	0.025	0.031	0.019	14.4	9.3	32 √	4.0	70 ±5
	±0.005	±0.001	±0.005	±0.005	±0.005	±0.002	±0.004	Max	±0.002	±0.005							

NOTES: (A) Inspect for flaws per MIL-STD-413 or Aerospace Standard AS-871. Inspection level shall be the tabulated AQL, Level II, per MIL-STD-105.

(B) 100% inspection is required for critical internal seals or for external seals where long-term sealing is required. For less critical applications, engineering judgment is required. Depending upon the critical nature of the application, an AQL of 1.5, 2.5 or 4.0 may be appropriate.