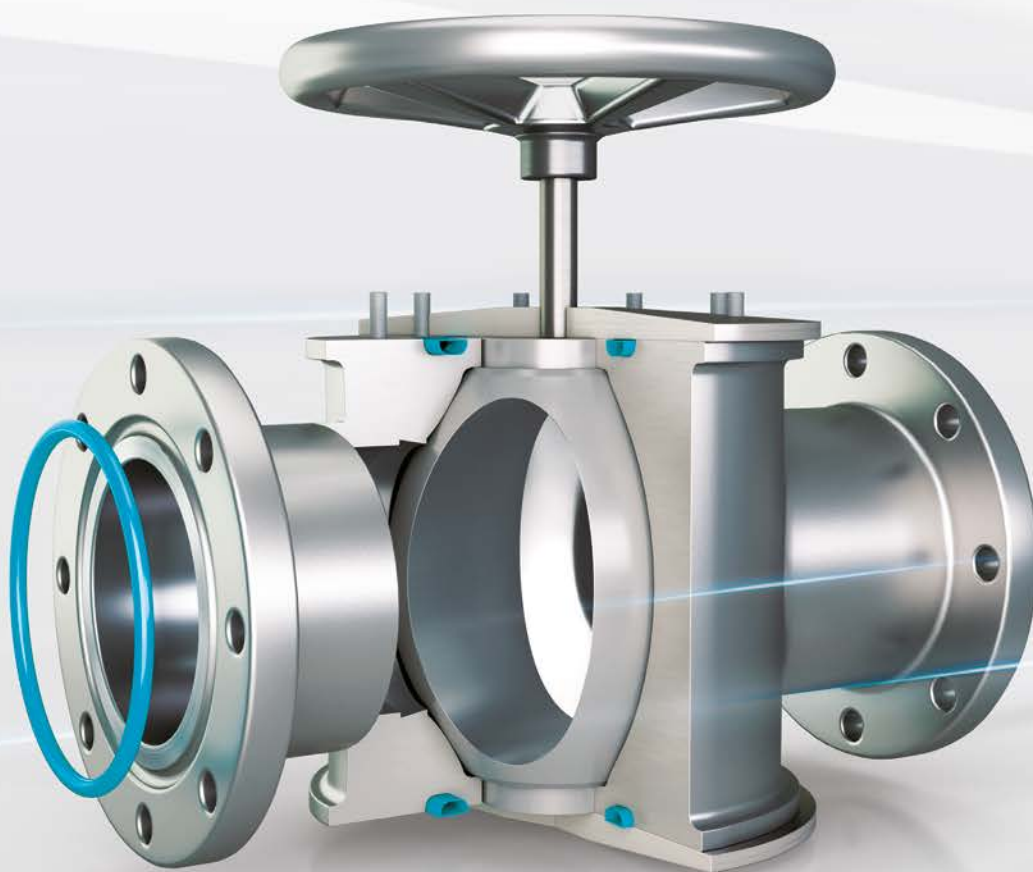


Wills Rings®





Your Partner for Sealing Technology

Trelleborg Sealing Solutions is a major international developer, manufacturer and supplier of seals, bearings and molded components in polymers. We are uniquely placed to offer dedicated design and development from our market-leading product and material portfolio: a one-stop-shop providing the best in elastomer, silicone, thermoplastic, PTFE and composite technologies for applications in aerospace, industrial and automotive industries.

With 50 years of experience, Trelleborg Sealing Solutions engineers support customers with design, prototyping, production, test and installation using state-of-the-art design tools. An international network of over 80 facilities worldwide includes over 20 manufacturing sites, strategically-positioned research and development centers, including materials and development laboratories and locations specializing in design and applications.

Developing and formulating materials in-house, we utilize the resource of our material database, including over 2,000

proprietary compounds and a range of unique products. Trelleborg Sealing Solutions fulfills challenging service requirements, supplying standard parts in volume or a single custom-manufactured component, through our integrated logistical support, which effectively delivers over 40,000 sealing products to customers worldwide.

Trelleborg Sealing Solutions facilities are certified according to current market-related quality standards. In addition to the established ISO 9001 standard, our facilities are certified to environmental, health and safety standards, as well as specific customer specifications. These certifications are in many cases prerequisites, allowing us to comply to all market segment requirements.



The information in this catalog is intended for general reference only and not for specific applications. Application limits for pressure, temperature, speed and media are maximum values determined in laboratory conditions. In application, due to operating parameters, maximum values may not be achievable. Customers must satisfy themselves of a product and material's suitability for their individual applications. Any reliance on information is therefore at the user's own risk. In no event will Trelleborg Sealing Solutions be liable for any loss, damage, claim or expense directly or indirectly arising or resulting from the use of any information provided in this catalog. While every effort is made to ensure the accuracy of information contained herewith, Trelleborg Sealing Solutions cannot warrant the accuracy or completeness of information.

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■ Introduction

Trelleborg Sealing Solutions designs and manufactures a wide range of seals and bearings for many industries and applications, including Wills Rings®, the original metal O-Ring seals. First developed at the Trelleborg Sealing Solutions facility in Bridgwater, UK, the term Wills Rings® has become synonymous with this type of seal and is internationally used as a generic term to describe metal O-Ring seals.

Superior controlled-compression type seals used in static applications which can withstand extreme conditions that exceed the capabilities of elastomer and polymer seals. The seals are constructed from high quality metal tubing or strip in standard or thin wall thicknesses and are often coated or plated with a softer material to increase their sealing performance.

Wills Rings® are available in two designs and five types (see Figure 1).

The designs are:

1) Wills Rings® O

Wills Rings® O consist of a tube formed into a circular profile.

2) Wills Rings® C

Wills Rings® C are similar to Wills Rings® O but with an open 'C' cross section. The open slot of the Wills Rings® C faces toward the system pressure and allows the seal to be pressure activated.

Typical applications for Wills Rings® :

- Nuclear power plants
- Furnaces
- Offshore and marine installations
- Cryogenic situations
- Ultra-high vacuum systems
- Fire safe valves
- Plastic processing plants
- High-performance vehicles

Wills Rings® can be customized to suit the specific requirements of a system. Contact your local Customer Solution Center for more information.

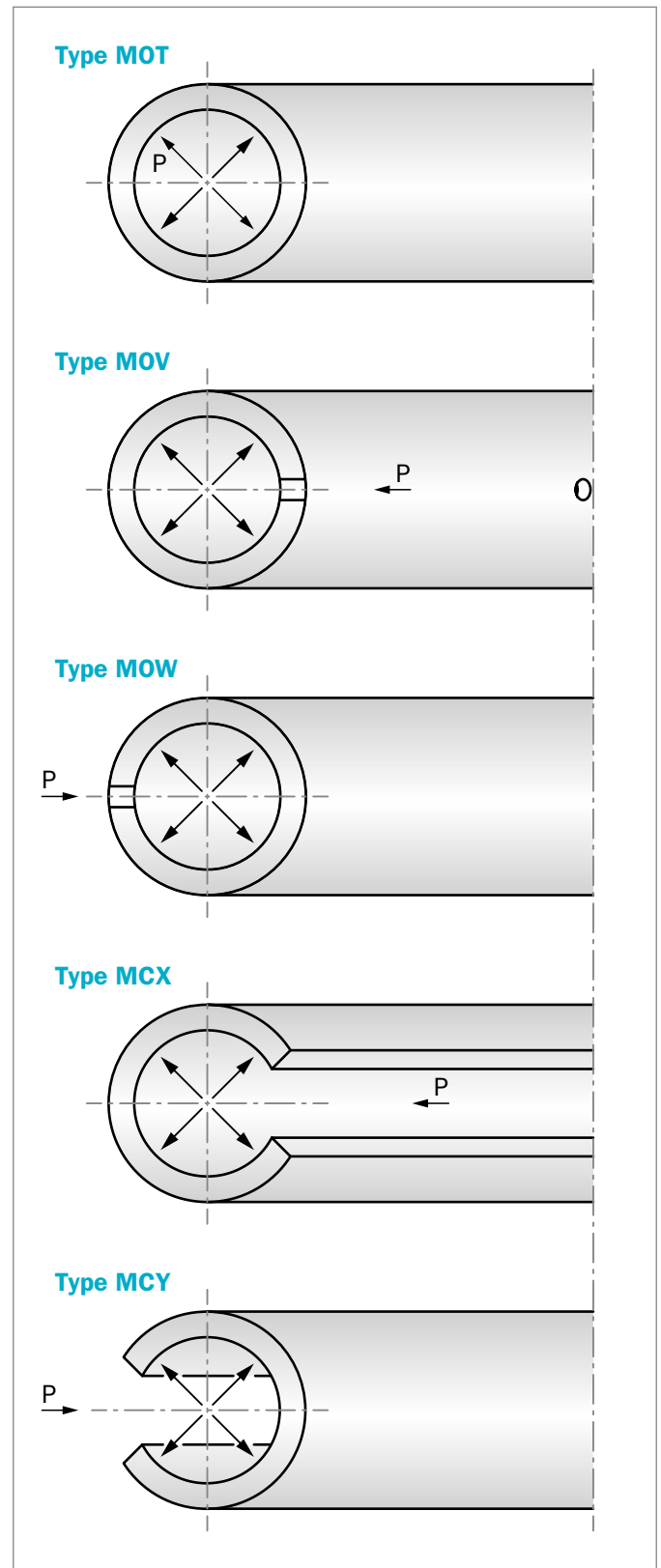


Figure 1: Wills Rings® variations



Method of Operation

Wills Rings® consist of a metal ring, often coated, which is used as a deformable seal in a static sealing situation. The ring is located between two flanges and undergoes a controlled compression.

Wills Rings® are defined by their free height, which is the cross section in the axial direction of the seal (Figure 2). The free height, d_2 , of the seal is compressed down to the groove depth, h .

The resistance of the ring to compression enables it to generate a sealing force when compressed. The resilient effect of the seal can be increased by pressurizing the internal volume of the ring (see Type MOT gas-filled Wills Rings® O).

Alternatively, if the system to be sealed is very high pressure, the pressure can be used to provide additional sealing effect. This is called system actuation and is achieved by allowing the pressure to enter the seal through vent holes (see Type MOV or the open C slot, Type MCX).

Wills Rings® have a certain degree of elasticity. This is known as springback. The springback is the elastic part of the seal deflection when it is installed in a groove. This dictates the seal's ability to absorb or compensate for hardware variations due to temperature and/or pressure loadings thus maintaining the seal integrity (Figure 2).

A softer plating or coating material can be applied to Wills Rings® to maximize sealing performance in demanding applications. The coating material yields during the ring compression and fills surface machining marks (Figure 3).

For best sealing results, Wills Rings® should be replaced each time the groove housing is dismantled as the plating material deforms from use and performance cannot be guaranteed again once the housing has been dismantled.

PERFORMANCE

Because Wills Rings® are constructed from metal, their ability to handle extreme conditions exceeds that of polymeric and elastomeric seal types.

Unlike elastomer seals, Wills Rings® are not subject to outgassing, making them suitable for use on equipment sensitive to it.

FEATURES AND BENEFITS

- Temperature range from cryogenic to +850 °C / +1,550 °F
- Pressure range from ultra-high vacuum to 1,000 MPa / 145,000 psi
- Compatible with a large range of media
- Corrosion resistant and radiation tolerant
- Simple and reliable sealing
- No outgassing
- Immune to rapid gas decompression
- Wide range of sizes

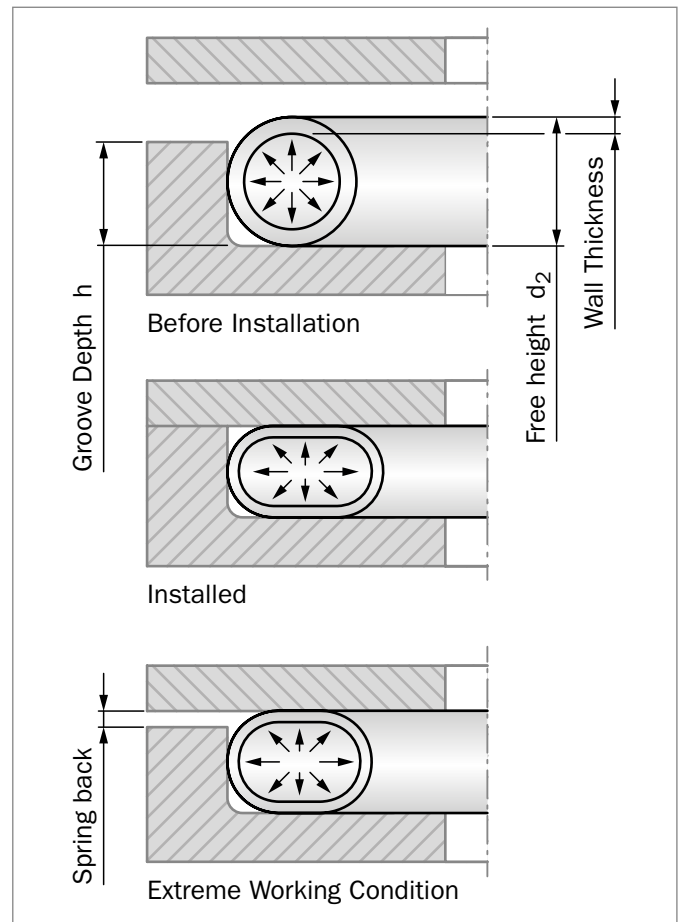


Figure 2: Method of seal operation

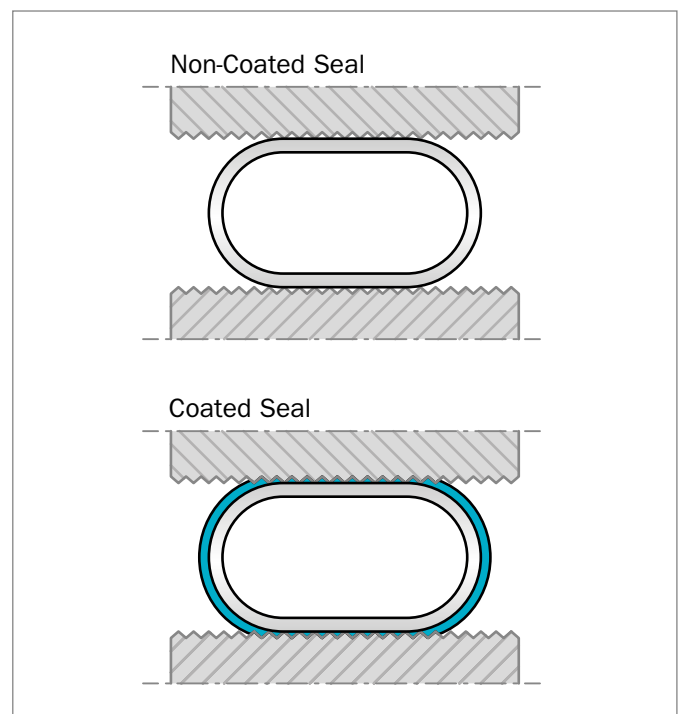


Figure 3: Contact surface for coated and non-coated Wills Rings®

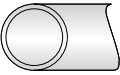
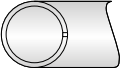

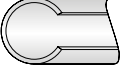



■ Selection Table

Use this table to select the optimum seal for an application. A, B or C indicates relative performance.

Further information can be found on the relevant pages as indicated.

Table 1: Selection Criteria

Seal			Extreme Conditions	Seating Loads	Spring-back	Vacuum Sealing	Pressure MPa/psi	Max. Working Temp. °C / °F	Standard Material	
Code	Page								Seal	Coating
 Type MOT	11	Pres-surized	A	C	C	1x10 ⁻⁹ mbar.l.s.-1	20 MPa 2,900 psi / 40 MPa 5,800 psi	850 °C 1,550 °F	Stainless Steel 316 L Stainless Steel 321 Inconel® 600	Silver Nickel
 Type MOV	11	Vented internal	B	B	C	-	1,000 MPa 145,000 psi	600 °C 1,100 °F		
 Type MOW	11	Vented external								
 Type MCX	12	Internal pressure	B	A	A	1x10 ⁻⁷ mbar.l.s.-1	200 MPa 29,000 psi	750 °C 1,375 °F	Inconel® X750 Inconel® 718	Silver Nickel
 Type MCY	12	External pressure								

Properties: A = Excellent B = Good C = Satisfactory

If further information on seal selection is required please contact your local Customer Solution Center. Inconel® is a trademark of INCO Alloys International, Inc.



Materials

SEAL MATERIAL

Available in a range of materials, Wills Rings® are used as static seals in a large number of industrial sectors. The choice of material affects the seal performance and materials should be chosen after considering the following requirements:

- Pressure and temperature
- Seating loads
- Corrosion resistance
- Compatibility with housing materials
- Length of life
- Sealing level
- Cost

INDUSTRY STANDARDS

For some industries, seal material selection can be critical and require compliance with industry standards.

For example, a Wills Rings® C with compliance to NACE MR0175 should be selected in material Inconel® 718 and be hardened using treatment 5 as shown in the part number tables.

Table 2: Standard Seal Materials for Wills Rings® O

Standard Material	Maximum Operating Temperature		Code
	°C	°F	
Stainless Steel AISI 316L (1.4435)	800	1,475	H
Stainless Steel AISI 321 (1.4541)	800	1,475	E
Inconel® 600	850	1,550	M

Table 3: Standard Seal Materials for Wills Rings® C

Standard Material	Maximum Operating Temperature		Code
	°C	°F	
Inconel® X750	750	1,375	N
Inconel® 718	750	1,375	L

Please note:

Not all materials are available in all sizes.

Alternative ring and plating materials can be offered. Please contact your local Customer Solution Center for details.



PLATING AND COATING MATERIALS FOR WILLS RINGS®

The sealing capability of Wills Rings® is greatly enhanced by the addition of a softer coating material (see Figure 3). Table 4 gives the technical data for each coating, including the plating thickness, temperature capability and size range.

Select plating and coatings for applications by considering the following system requirements:

1. Level of sealing needed and the fluid to be sealed
2. Operating temperature
3. Compatibility with media

For higher levels of sealing, more layers of plating should be combined with a better surface finish.

Note:

Increased plating and a better surface finish make the seal and the hardware more expensive to produce.

For less critical applications, non-plated rings may provide sufficient sealing.

Contact your local Customer Solution Center for further information.

Table 4: Standard Coating Materials

Coating		Coating-Thickness		Temperature		Comments	Max. Ø	
Material	Code	mm	inch	°C	°F		mm	inch
Nickel	Q	0.025-0.038	0.001-0.0015	1,200	2,200	-	1,000	39
Silver	R	0.025-0.038	0.001-0.0015	800	1,475	1 layer silver	1,000	39
Silver	U	0.050-0.063	0.002-0.0025	800	1,475	2 layers silver	1,000	39
Silver	S	0.075-0.088	0.003-0.0035	800	1,475	3 layers silver	1,000	39

Note:

Nickel coating requires activation at +400 °C (+752 °F) or higher before full sealing performance is achieved.



■ Hardware, Finish and Media

Table 5 shows the media that can be sealed with different plating materials and the required surface finish for the housing. It is important that all machining marks are concentric with the line of seal contact. Spiral or radial marks should be avoided as these can form leak paths across the seal face.

The groove should be machined to the required finish and not polished by hand. Polishing can lead to radial marks on the sealing surface which may form leak paths.

Typically a thin gas is more difficult to seal than a heavy liquid, and requires a better surface finish. The lower the media viscosity, the higher the surface finish quality and plating level required.

Table 5: Media and Hardware Surface Finishes

Sealing System/Media	Ra		Rmax.		Typical Plating	Comments
	µ m	µ inch	µ m	µ inch		
Ultra-high vacuum	0.1 - 0.2	4 - 8	1.2 - 1.6	48 - 64	S	Use this for safety critical systems
Cryogenic - High vacuum	0.1 - 0.2	4 - 8	1.2 - 1.6	48 - 64	S	
Helium, Hydrogen	0.1 - 0.2	4 - 8	1.2 - 1.6	48 - 64	S	-
Nitrogen, Steam	0.2 - 0.4	8 - 16	2.0 - 2.5	80 - 100	R/S	
Cryogenic - Light vacuum	0.2 - 0.4	8 - 16	2.0 - 2.5	80 - 100	R/S	-
Air, Water, Light fuel	0.4 - 0.8	16 - 32	3.0 - 4.0	120 - 160	R	Non-plated rings may be suitable
Heavy oils, Polymer	0.4 - 0.8	16 - 32	3.0 - 4.0	120 - 160	R	



■ Wills Rings® O Type MOT (Gas Filled)

The most frequently used Wills Rings® are filled with nitrogen gas. The gas pressure inside the seal rises with temperature to offset the loss of tubing strength at elevated temperatures.

ADVANTAGES

- High temperature capability
- Available in a wide range of materials and finishes
- Resistant to corrosion, chemical attack and radiation
- Long life
- Resilient (springback)

TECHNICAL DATA

Operating Pressure:	Vacuum - helium tight 1×10^{-9} mbar.l.s ⁻¹ Thin wall up to 20 MPa / 2,900 psi Standard wall up to 40 MPa / 5,800 psi
Temperature:	Cryogenic to +850 °C / +1,550 °F (constant temperature)
Seal Type:	Internal and external pressure sealing
Standard Materials:	Stainless Steel/Inconel
Coating Materials:	Nickel Silver

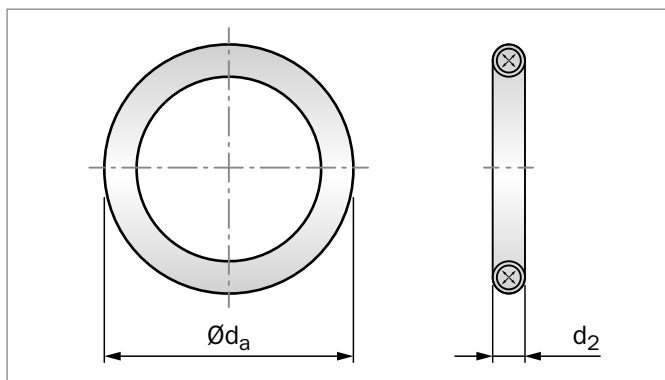


Figure 4: Wills Rings® O - Type MOT

■ Wills Rings® O Type MOV Internal Pressure Type MOW External Pressure (System Pressure Actuated)

These seals are ideal for extreme pressure applications. System pressure actuates the seal ring through vent holes on the seal wall. The vent holes are on the inside diameter for internal pressure (Type MOV), and on the outside diameter for external pressure systems (Type MOW).

These vent holes enable the internal pressure of the seal to equal the system pressure.

ADVANTAGES

- High pressure capability
- Available in a wide range of materials and finishes
- Resistant to corrosion, chemical attack and radiation
- Long life

TECHNICAL DATA

Operating Pressure:	7 to 1,000 MPa / 1,015 to 145,000 psi
Temperature:	Cryogenic to +600 °C / +1,100 °F (constant temperature)
Seal Type:	Internal and external pressure sealing
Standard Materials:	Stainless Steel/Inconel
Coating Materials:	Nickel Silver

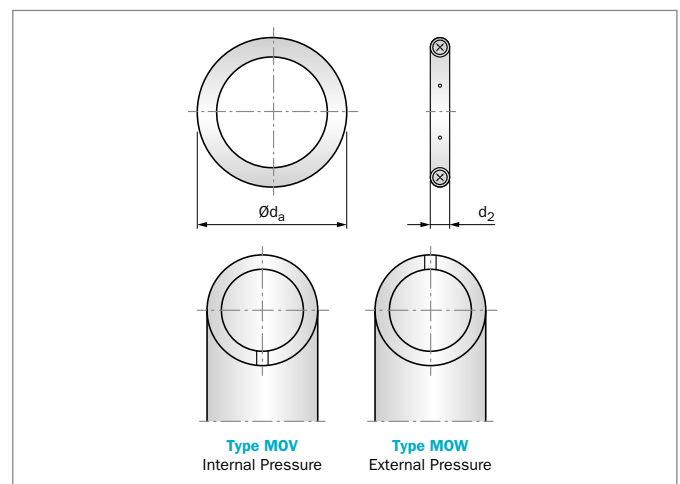


Figure 5: Wills Rings® O - Type MOV internal vented / MOW external vented



■ Wills Rings® C
Type MCX Internal Pressure
Type MCY External Pressure

System pressure actuates the seal through a vent slot in the C profile that runs around the entire circumference of the seal. This slot is internal for internal pressure, and external for external pressure systems.

A key benefit of this seal type is an increased amount of seal springback. This can be triple the amount exhibited by metal Wills Rings® O seals. Also, by using a thin wall section, low seating loads can be achieved.

ADVANTAGES

- Low seating loads
- High springback
- Good pressure and temperature capability
- Long life
- Resistant to corrosion, chemical attack and radiation

TECHNICAL DATA

Pressure:	Vacuum - bubble tight 5 x 10 ⁻⁷ mbar.l.s ⁻¹ to 200 MPa / 29,000 psi
Temperature:	Cryogenic to 750 °C / 1,375 °F
Seal type:	Internal and external pressure sealing
Seal materials:	Inconel® X750 Inconel® 718
Coating materials:	Nickel Silver

Note:

For internal pressure, Wills Rings® C type MCX are sized to their outside diameter, Ø d_a.

For external pressure, Wills Rings® C type MCY are sized to their inside diameter, Ø d_i.

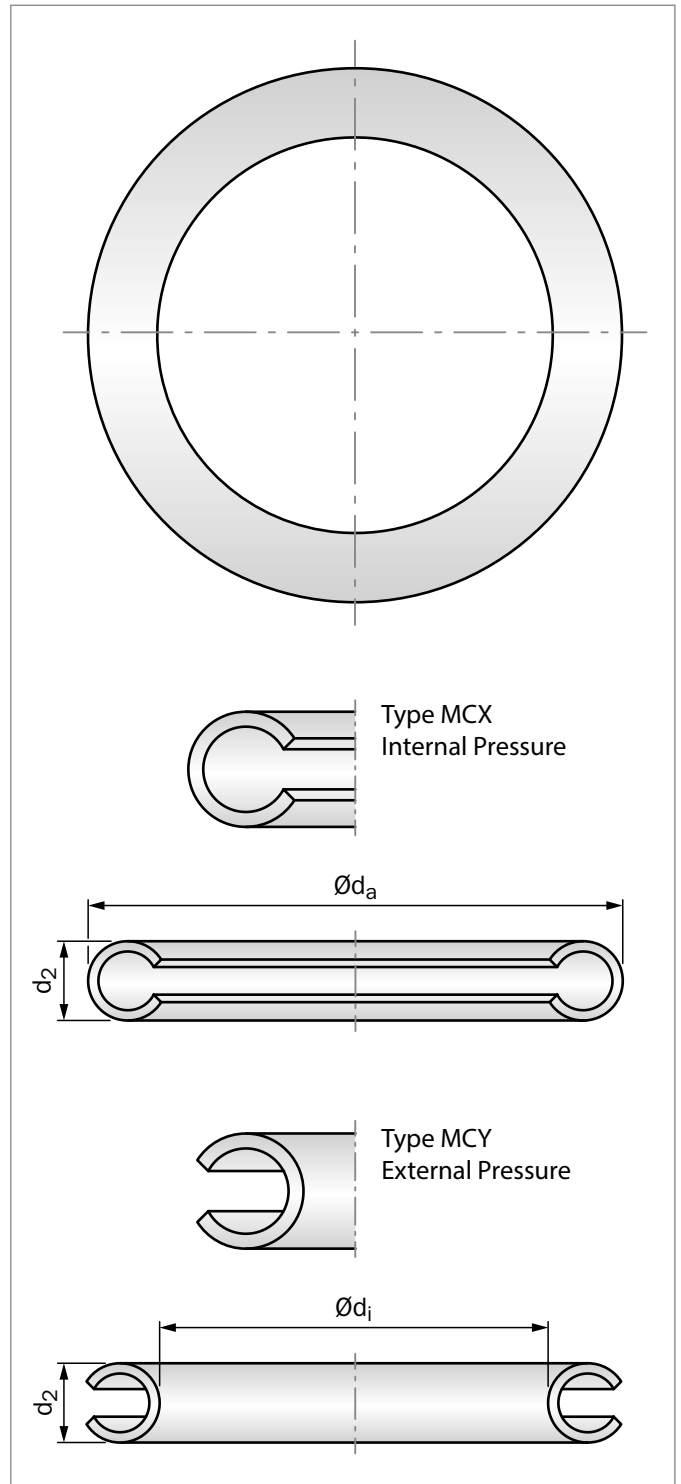


Figure 6: Wills Rings® C - Type MCX / MCY



■ Compression Loads to Seat Wills Rings®

Seating the seal is the process of compressing it to the correct depth, such that it forms an effective seal.

When Wills Rings® are located in a housing, a specific load must be applied to the flanges to seat the seals correctly.

The required seating load must be calculated for each seal and must be exceeded by the system load used to secure the sealing flanges together. The system pressure for internal pressure systems also has an effect on the clamping forces. This pressure acts on an area inside the seal diameter causing an extra load on the clamping system.

Minimum seating load required:

$$LT = L1 + L2$$

Where: LT = Total required seating load
 L1 = Load to seat seal
 L2 = Load caused by internal system pressure

The securing system must be sufficiently strong to withstand the pressure and temperature effects during system operation. Most Wills Rings® are available in standard and thin wall sections. Generally, standard wall seals should be used wherever possible. A standard wall thickness ring is stronger and forms a more effective seal. A thin wall seal should be used to provide lower seating loads if required.

FACTORS AFFECTING THE SYSTEM DESIGN AND THE SEATING LOAD OF A SEAL ARE:

- Loss of bolt strength at elevated temperatures
- Increases in pressure at elevated temperatures
- Creep losses/relaxation over time
- The bolt loads holding the system must be sufficient to seat Wills Rings® and withstand the system pressure
- The system flanges must be strong enough to avoid deformation

Note:

Wills Rings® C can be hardened to modify the seal resilience. The seating load figures given in Table 9 are for standard treatment seals only (Code Number 2 - short cycle age-hardened). If a non-standard seal treatment is used (see Table 6 for options), then the correct material factor must be used in the seating load calculation, see Table 7 and Table 8.

All figures given for seating loads are typical values only.

It is recommended that seal users apply an appropriate safety margin in all calculations for the seating loads relative to the sealing requirements.

Tests should be conducted to establish suitability of the clamping system.

Table 6: Wills Rings® C

Code	Treatment
1	Work-harden
2	Age-harden (short cycle)
3	Age-harden (long cycle)
4	Solution anneal and age-harden
5	Heat treat to NACE MR0175

Note:

Material condition has an influence on the seating load, see Table 8.

HARDNESS/SEAL RESILIENCE

Age-hardened Wills Rings® C have higher seal resilience. This is required for silver coated Wills Rings® C in order to apply sufficient seating force to deform the coating.

Age-hardening (short cycle) is adequate for normal sealing.

Age-hardening (long cycle) can be used to provide higher seating loads offering greater seal resilience which assists with sealing in extreme conditions.

The hardness treatment code **must** be included in the Wills Rings® C part numbers (see the ordering example on page 27).



■ Calculating Seating Loads

The compressive load required to correctly seat specific Wills Rings® in the recommended groove depends on the seal diameter, seal free height, wall thickness and seal material according to the following expression:

$$L1 = M \times K \times D_m \times \pi$$

Where:

- L1 = Load to seat the seal (N)
- M = Material factor (see Table 7 or Table 8)
- K = Load in N/mm seal circumference (see Table 9)
- D_m = Median (sealing) diameter of the seal, d_a - d₂ (mm)
- π = Pythagoras constant (3.142)

Table 7: Material Factor Wills Rings® O

Material Factor	M
Stainless steel AISI 316L (1.4435)	1.00
Stainless steel AISI 321 (1.4541)	1.00
Inconel® 600	1.10

Table 8: Material Factor Wills Rings® C

Material Factor	M
Inconel® X750	0.85
Inconel® 718	1.00

Note:
 Use M x 0.75 for work harden
 Use M x 1.20 for age-harden (long cycle)

Table 9: Compressive Load for Standard Wall Wills Rings®

Cross Section			Size Code	Wills Rings® O				Wills Rings® C			
				Wall Thickness		Seating Load Circumference		Wall Thickness		Seating Load Circumference	
mm	inch	mm		inch	N/mm	lb/inch	mm	inch	N/mm	lb/inch	
1.59	0.063	std	A	0.36	0.014	161	919	0.25	0.010	51	291
		thin	K	0.25	0.010	98	560	0.15	0.006	15	86
2.38	0.094	std	B	0.46	0.018	198	1131	0.38	0.015	69	394
		thin	L	0.25	0.010	52	297	0.25	0.010	28	160
3.18	0.125	std	C	0.51	0.020	176	1,005	0.51	0.020	100	571
		thin	M	0.25	0.010	65	371	0.38	0.015	62	354
3.97	0.156	std	D	0.64	0.025	253	1,445	0.61	0.024	111	634
		thin	N	0.25	0.010	46	263	0.41	0.016	46	263
4.76	0.187	std	E	0.81	0.032	280	1,599	0.76	0.030	141	805
		thin	O	0.25	0.010	37	212	0.51	0.020	63	360
6.35	0.250	std	F	1.02	0.040	100	571	-	-	-	-
		thin	P	0.51	0.020	52	297	0.64	0.025	66	377

Note:
 The seating loads listed are a general guide and not intended to be used as design criteria. Many factors can influence the required seating load. Please contact your local Customer Solution Center for a specific recommendation for your application.



The compressive load required to correctly seat specific Wills Rings® in the recommended groove depends on the seal type, seal diameter, free height, wall thickness and seal material, as described on the previous page.

diameter. Typically standard wall Wills Rings® O will require twice the seating load of standard wall Wills Rings® C.

Figure 7 is a graph showing how seal types compare to each other for a given seal cross section, wall thickness and

Table 9 on the previous page gives typical seating loads for each type and cross-section of Wills Rings® and the graph below demonstrates how these measurements are taken.

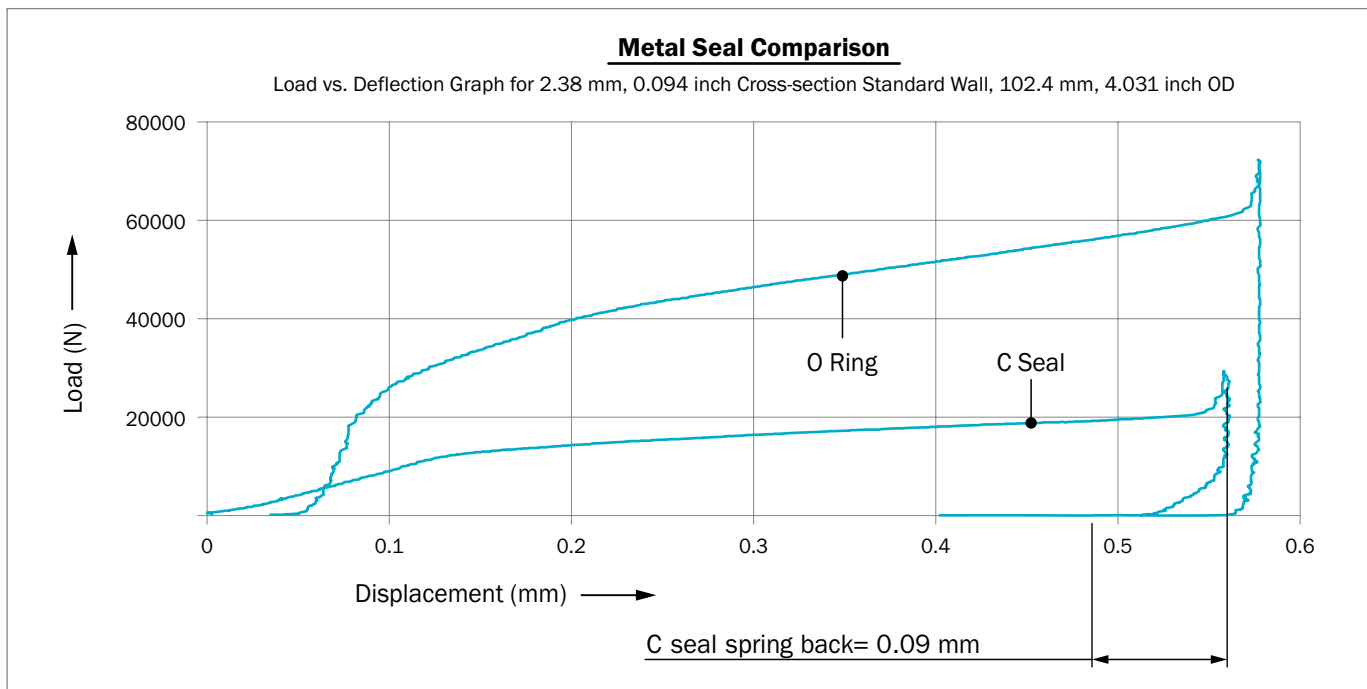


Figure 7: Graph detailing load vs. deflection comparison of two Wills Rings® types

Note:

It is not recommended to compress the seal less than the recommended amount in order to reduce the amount of load required to seat the seal. Using deeper grooves to reduce seating load could have an adverse effect on sealing efficiency. If lower seating loads are required, the correct seal type should be chosen with the correct coating.



■ Groove Designs

There are several types of groove which may be employed to house Wills Rings® depending upon the application and the system requirements, see Figure 9.

13.1 CLOSED GROOVE

The seal is enclosed on its inside and outside diameters.

13.2 OPEN GROOVE

The seal is enclosed by a groove wall opposing the pressure direction. For example, for internal pressure, the groove wall is on the outside of the seal.

13.3 RETAINER PLATE

If no groove can be constructed, then a plate of equal depth to the groove can be used to provide support to the seal.

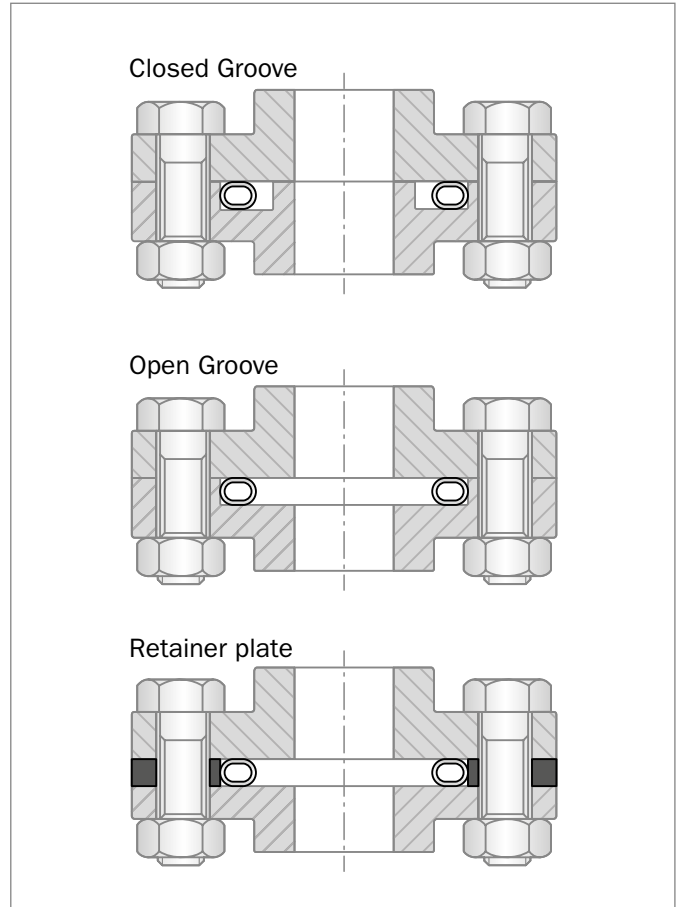


Figure 9: Common installation configurations for Wills Rings®

All installations above show Wills Rings® O installations.

The same housings can be used for Wills Rings® C installations.

See Figure 10 and comments for Wills Rings® O within an automotive groove.

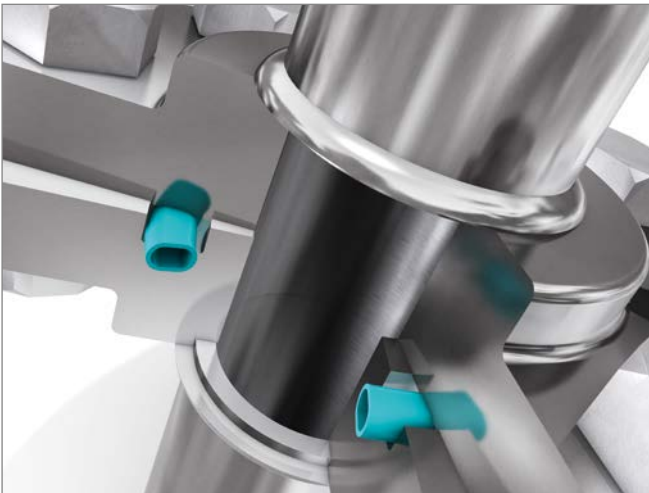


Figure 8: Example of Wills Rings® within its groove



AUTOMOTIVE GROOVE

Another useful method of seal housing is using the automotive groove approach. This seal housing is commonly used for high-performance engines to seal the cylinder head to the engine block. Typically Wills Rings® O gas-filled seals are used here. Where cyclical engine pressures are found, this groove securely holds the Wills Rings® in place. Also the trapped volume of a closed groove is eliminated.

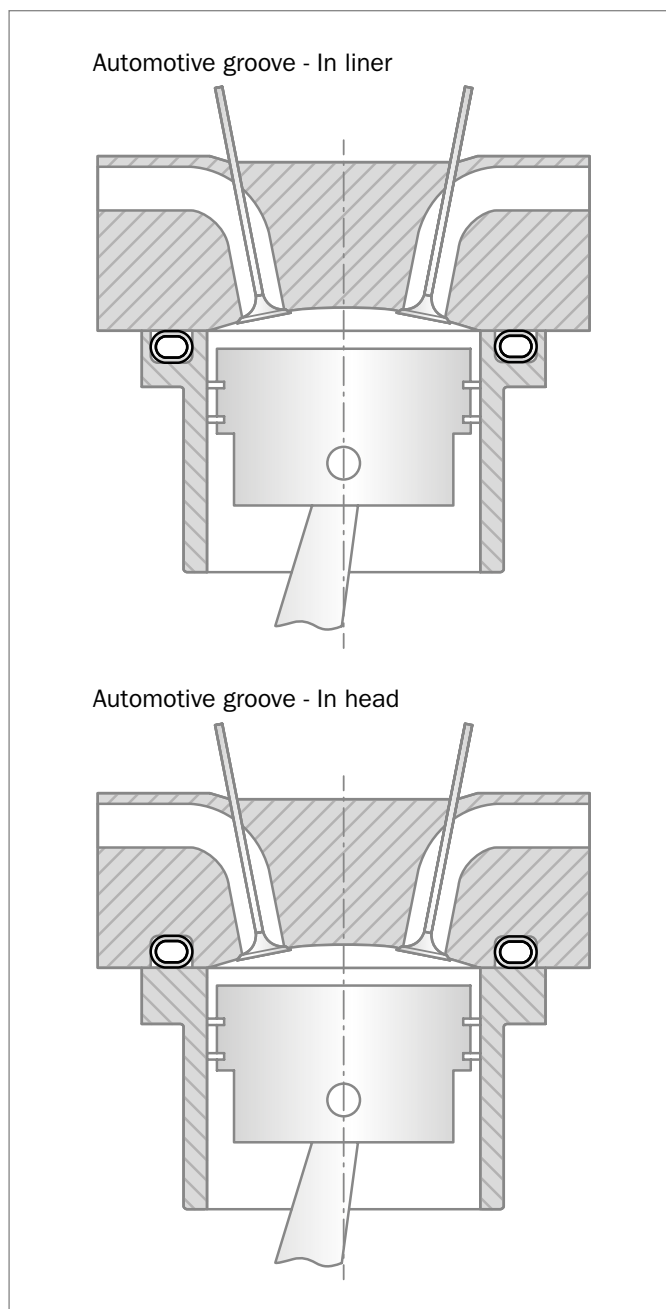


Figure 10: Common automotive installation configurations for Wills Rings® O

Figure 11 shows the preferred groove design for extreme cyclical pressures. The housing has a clearance from the seal inside and outside diameters, and the groove has a curved base. This design means the seal is held very securely and is protected from the media.

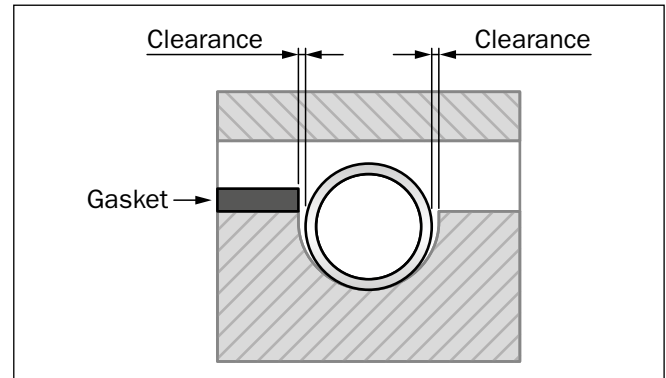


Figure 11: Detail of an automotive groove

The groove depth given for each free height, d_2 , is the total compressed depth of Wills Rings® when installed. If an additional form of sealing is to be used, for example a gasket, then the machined depth of the housing groove must be less, which can be calculated using the following expression:

$$h = M_d + G_d$$

Where:

- h = Groove depth (overall)
- M_d = Machined depth
- G_d = Crushed gasket depth

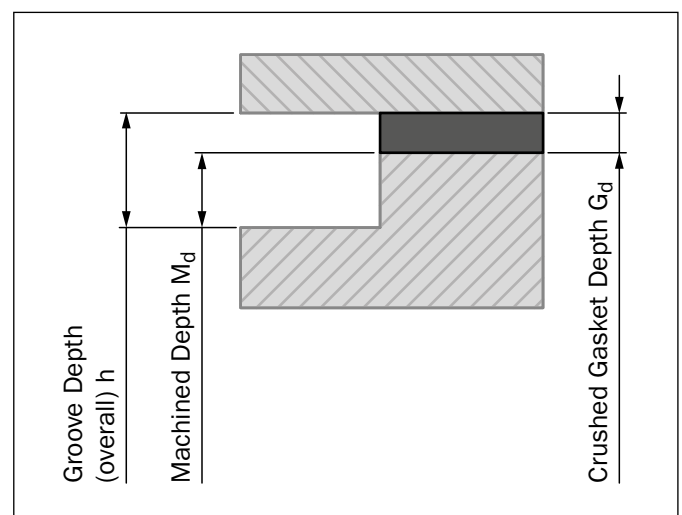


Figure 12: Wills Rings® groove depth with a gasket

For dimensions for automotive grooves, please contact your local Customer Solution Center.



■ Part Numbers and Ordering Instructions in Metric

INSTALLATION RECOMMENDATIONS FOR INTERNAL PRESSURE SEALING

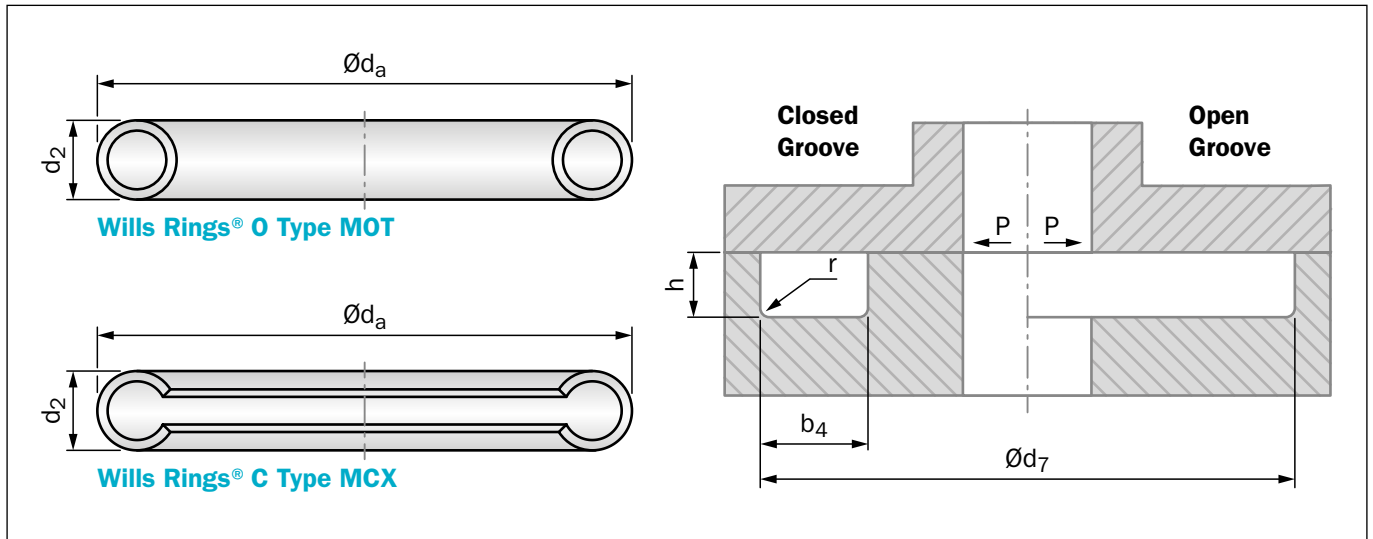


Figure 13: Installation drawing for internal pressure

Table 10: Installation Dimensions for Internal Pressure

Free Height d_2 mm	Wills Rings® O		Wills Rings® C		Groove Depth h	Groove Width 1) b_4 min.	Wills Rings® O $\varnothing d_a$	Wills Rings® C $\varnothing d_a$	Groove Diameter d_7 , unplated only 2) = d_a + clearance + tolerance		Radius r_{max} mm	Wills Rings® Springback	
	Free Height Mat. Codes Stand. Thin	Free Height Mat. Codes Stand. Thin	Free Height Mat. Codes Stand. Thin	Free Height Mat. Codes Stand. Thin					O only	C only			
1.59	A		A		1.32 +0.08 -0	2.25	12-150	20-150	$d_a + 0.10$	+0.05	0.40	0.02	0.06
		K	K	0.03								0.07	
2.38	B		B		1.83 +0.08 -0	3.00	25-500 50-500	25-300	$d_a + 0.18$	+0.12	0.50	0.04	0.09
		L	L	0.06								0.11	
3.18	C		C		2.54 +0.13 -0	4.00	60-1,000	50-300	$d_a + 0.18$	+0.12	0.75	0.05	0.12
		M	M	0.11								0.14	
3.97	D		D		3.05 +0.13 -0	5.00	100-1,250	60-300	$d_a + 0.18$	+0.12	1.25	0.06	0.11
		N	N	0.13								0.16	
4.76	E		E		3.68 +0.13 -0	6.00	115-1,500 150-1,500	95-300	$d_a + 0.25$	+0.12	1.50	0.08	0.12
		O	O	0.17								0.23	
6.35	F		-		5.08 +0.13 -0	8.00	125-2,000	115-300	$d_a + 0.25$	+0.12	1.50	0.10	0.27
		P	P	0.14								-	

Notes:

1) Minimum value. Recommended groove width $1.5 \times d_2$.

2) Calculate exact groove/seal \varnothing by the expression:

$$d_7 = d_a + (2 \times \text{maximum coating thickness}) + \text{clearance (+ tol.)}$$

$$= d_a + \text{CTCV page 25 (Table 18), for clearance tolerance correction value}$$

Example:

3.18 mm Wills Rings® C with three layers of plating

$$d_7 = d_a + (2 \times 3 \text{ layer coating} = 2 \times 0.085 \text{ mm} = 0.170 \text{ mm}) + \text{clearance (+ tol.)}$$

$$= d_a + 0.170 + \text{clearance (+ tol.)}$$

$$= d_a + 0.170 + 0.18 (+0.12)$$



WILLS RINGS® O FOR INTERNAL PRESSURE

These are typical of seal part numbers that can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the ordering example on page 26 and the seal data. See also page 8 and page 9, Table 2 to Table 4.

Table 11: Preferred Sizes Wills Rings® O, Metric

Seal Diameter	Seal Non-plated	Groove Ød ₇ H9	Seal 1 Layer	Groove Ød ₇ H9	Minimum Groove Width b ₄	Groove Depth h
15	MOT A R0150-1_	15.15	MOT A R0150-1_R	15.22	2.25	1.32/1.40
20	MOT A R0200-1_	20.15	MOT A R0200-1_R	20.22	2.25	1.32/1.40
25	MOT A R0250-1_	25.15	MOT A G0250-1_R	25.22	2.25	1.32/1.40
30	MOT B R0300-1_	30.30	MOT B R0300-1_R	30.37	3.00	1.83/1.91
35	MOT B R0350-1_	35.30	MOT B R0350-1_R	35.37	3.00	1.83/1.91
40	MOT B R0400-1_	40.30	MOT B R0400-1_R	40.37	3.00	1.83/1.91
45	MOT B R0450-1_	45.30	MOT B R0450-1_R	45.37	3.00	1.83/1.91
50	MOT B R0500-1_	50.30	MOT B R0500-1_R	50.37	3.00	1.83/1.91
55	MOT B R0550-1_	55.30	MOT B R0550-1_R	55.37	3.00	1.83/1.91
60	MOT B R0600-1_	60.30	MOT B R0600-1_R	60.37	3.00	1.83/1.91
65	MOT C R0650-1_	65.30	MOT C R0650-1_R	65.37	4.00	2.54/2.67
70	MOT C R0700-1_	70.30	MOT C R0700-1_R	70.37	4.00	2.54/2.67
75	MOT C R0750-1_	75.30	MOT C R0750-1_R	75.37	4.00	2.54/2.67
80	MOT C R0800-1_	80.30	MOT C R0800-1_R	80.37	4.00	2.54/2.67
85	MOT C R0850-1_	85.30	MOT C R0850-1_R	85.37	4.00	2.54/2.67
90	MOT C R0900-1_	90.30	MOT C R0900-1_R	90.37	4.00	2.54/2.67
95	MOT C R0950-1_	95.30	MOT C R0950-1_R	95.37	4.00	2.54/2.67
100	MOT C R1000-1_	100.30	MOT C R1000-1_R	100.37	4.00	2.54/2.67
110	MOT D R1100-1_	110.30	MOT D R1100-1_R	110.37	5.00	3.05/3.18
120	MOT D R1200-1_	120.30	MOT D R1200-1_R	120.37	5.00	3.05/3.18
130	MOT D R1300-1_	130.30	MOT D R1300-1_R	130.37	5.00	3.05/3.18
140	MOT D R1400-1_	140.30	MOT D R1400-1_R	140.37	5.00	3.05/3.18
150	MOT D R1500-1_	150.30	MOT D R1500-1_R	150.37	5.00	3.05/3.18
160	MOT D R1600-1_	160.30	MOT D R1600-1_R	160.37	5.00	3.05/3.18
170	MOT E R1700-1_	170.37	MOT E R1700-1_R	170.44	6.00	3.68/3.81
180	MOT E R1800-1_	180.37	MOT E R1800-1_R	180.44	6.00	3.68/3.81
190	MOT E R1900-1_	190.37	MOT E R1900-1_R	190.44	6.00	3.68/3.81
200	MOT E R2000-1_	200.37	MOT E R2000-1_R	200.44	6.00	3.68/3.81
250	MOT E R2500-1_	250.37	MOT E R2500-1_R	250.44	6.00	3.68/3.81

Use this selection when designing a new housing/sealing system

Also applies to Wills Rings® O for Type MOV.

Note:

These seal part numbers use ring sizing (indicated by “R” in the Ø code). The seal diameter has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value, see Table 18 on page 25.

**WILLS RINGS® C FOR INTERNAL PRESSURE**

These are typical of seal part numbers that can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the ordering example on page 27 and the seal data. See also page 8 and page 9, Table 2 to Table 4.

Table 12: Preferred Sizes Wills Rings® C, Metric

Seal Diameter	Seal Non-plated	Groove Ød ₇ H9	Seal 1 Layer	Groove Ød ₇ H9	Minimum Groove Width b ₄	Groove Depth h
20	MCX A R0200-1_2	20.15	MCX A R0200-1_R2	20.22	2.25	1.32/1.40
25	MCX A R0250-1_2	25.15	MCX A R0250-1_R2	25.22	2.25	1.32/1.40
30	MCX A R0300-1_2	30.15	MCX A R0300-1_R2	30.22	2.25	1.32/1.40
35	MCX A R0350-1_2	35.15	MCX A R0350-1_R2	35.22	2.25	1.32/1.40
40	MCX A R0400-1_2	40.15	MCX A R0400-1_R2	40.22	2.25	1.32/1.40
50	MCX A R0500-1_2	50.15	MCX A R0500-1_R2	50.22	2.25	1.32/1.40
30	MCX B R0300-1_2	30.30	MCX B R0300-1_R2	30.37	3.00	1.83/1.91
40	MCX B R0400-1_2	40.30	MCX B R0400-1_R2	40.37	3.00	1.83/1.91
50	MCX B R0500-1_2	50.30	MCX B R0500-1_R2	50.37	3.00	1.83/1.91
60	MCX B R0600-1_2	60.30	MCX B R0600-1_R2	60.37	3.00	1.83/1.91
70	MCX B R0700-1_2	70.30	MCX B R0700-1_R2	70.37	3.00	1.83/1.91
80	MCX B R0800-1_2	80.30	MCX B R0800-1_R2	80.37	3.00	1.83/1.91
90	MCX B R0900-1_2	90.30	MCX B R0900-1_R2	90.37	3.00	1.83/1.91
70	MCX C R0700-1_2	70.30	MCX C R0700-1_R2	70.37	4.00	2.54/2.67
80	MCX C R0800-1_2	80.30	MCX C R0800-1_R2	80.37	4.00	2.54/2.67
90	MCX C R0900-1_2	90.30	MCX C R0900-1_R2	90.37	4.00	2.54/2.67
100	MCX C R1000-1_2	100.30	MCX C R1000-1_R2	100.37	4.00	2.54/2.67
110	MCX C R1100-1_2	110.30	MCX C R1100-1_R2	110.37	4.00	2.54/2.67
150	MCX C R1500-1_2	150.30	MCX C R1500-1_R2	150.37	4.00	2.54/2.67
110	MCX D R1100-1_2	110.30	MCX D R1100-1_R2	110.37	5.00	3.05/3.18
120	MCX D R1200-1_2	120.30	MCX D R1200-1_R2	120.37	5.00	3.05/3.18
130	MCX D R1300-1_2	130.30	MCX D R1300-1_R2	130.37	5.00	3.05/3.18
140	MCX D R1400-1_2	140.30	MCX D R1400-1_R2	140.37	5.00	3.05/3.18
150	MCX D R1500-1_2	150.30	MCX D R1500-1_R2	150.37	5.00	3.05/3.18
160	MCX D R1600-1_2	160.30	MCX D R1600-1_R2	160.37	5.00	3.05/3.18
160	MCX E R1600-1_2	160.37	MCX E R1600-1_R2	160.44	6.00	3.68/3.81
170	MCX E R1700-1_2	170.37	MCX E R1700-1_R2	170.44	6.00	3.68/3.81
180	MCX E R1800-1_2	180.37	MCX E R1800-1_R2	180.44	6.00	3.68/3.81
190	MCX E R1900-1_2	190.37	MCX E R1900-1_R2	190.44	6.00	3.68/3.81
200	MCX E R2000-1_2	200.37	MCX E R2000-1_R2	200.44	6.00	3.68/3.81
160	MCX P R1600-1_2	160.37	MCX P R1600-1_R2	160.44	8.00	5.08/5.21
170	MCX P R1700-1_2	170.37	MCX P R1700-1_R2	170.44	8.00	5.08/5.21
180	MCX P R1800-1_2	180.37	MCX P R1800-1_R2	180.44	8.00	5.08/5.21
190	MCX P R1900-1_2	190.37	MCX P R1900-1_R2	190.44	8.00	5.08/5.21
200	MCX P R2000-1_2	200.37	MCX P R2000-1_R2	200.44	8.00	5.08/5.21

Use this selection when designing a new housing/sealing system.

Note:

These seal part numbers use ring sizing (indicated by "R" in the Ø code). The seal diameter has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value, see Table 18 on page 25.



INSTALLATION RECOMMENDATIONS FOR EXTERNAL PRESSURE SEALING

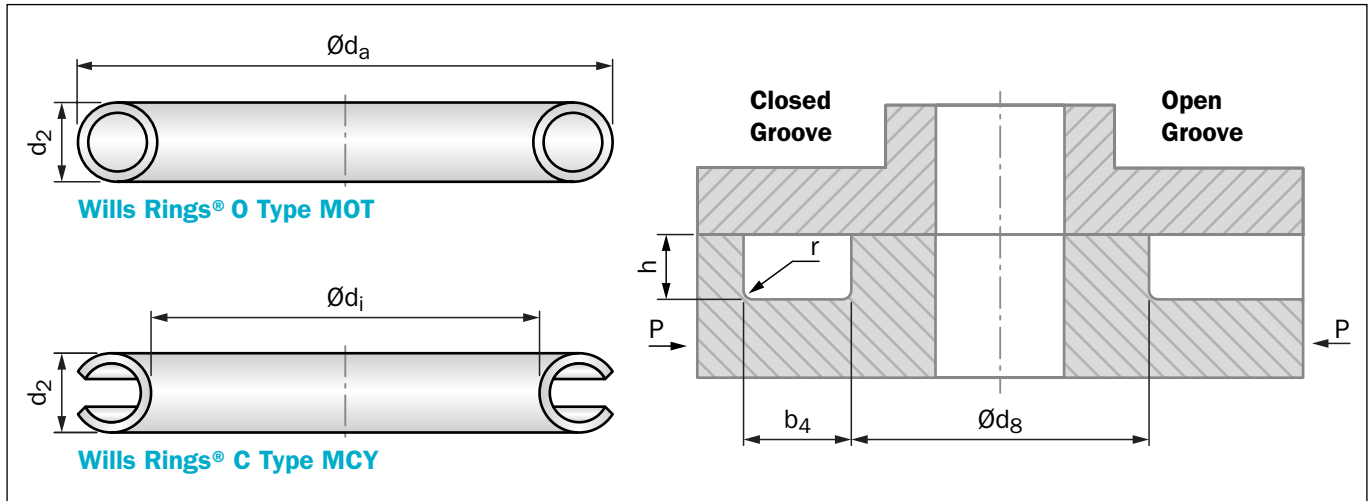


Figure 14: Installation drawing for external pressure

Table 13: Installation Dimensions for External Pressure

Free Height d_2 mm	Wills Rings® O		Wills Rings® C		Groove Depth		Groove Width 1)		Wills Rings® O 2)	Wills Rings® C	Groove Diameter d_g , unplated only 3) = d_i - clearance + tolerance		Radius r_{max} mm	Wills Rings® Springback	
	Free Height Mat. Codes Stand.	Thin	Free Height Mat. Codes Stand.	Thin	h	b_4 min.	$\varnothing d_a$	$\varnothing d_i$	$\varnothing d_a$	$\varnothing d_i$	mm	O only		C only	
1.59		A		A	1.32	+0.08	2.25	12-150	20-150	d_i -0.10	-0.05	0.40	0.02	0.06	
	K		K			-0							0.03	0.07	
2.38		B		B	1.83	+0.08	3.00	25-500	25-300	d_i -0.18	-0.12	0.50	0.04	0.09	
	L		L			-0		50-500					0.06	0.11	
3.18		C		C	2.54	+0.13	4.00	60-1000	50-300	d_i -0.18	-0.12	0.75	0.05	0.12	
	M		M			-0							0.11	0.14	
3.97		D		D	3.05	+0.13	5.00	100-1250	60-300	d_i -0.18	-0.12	1.25	0.06	0.11	
	N		N			-0							0.13	0.16	
4.76		E		E	3.68	+0.13	6.00	115-1500	95-300	d_i -0.25	-0.12	1.50	0.08	0.12	
	O		O			-0		150-1500					0.17	0.23	
6.35		F		-	5.08	+0.13	8.00	125-2000	115-300	d_i -0.25	-0.12	1.50	0.10	0.27	
	P		P			-0							0.14		

Notes:

- 1) Minimum value. Recommended is groove width $1.5 \times d_2$.
- 2) $d_a = d_i + (2 \times d_2)$
- 3) Calculate exact groove/seal \varnothing by the expression:
 $d_g = d_i - (2 \times \text{maximum coating thickness}) - \text{clearance} (- \text{tol.})$
 $= d_i - \text{CTCV page 25 (Table 18), for clearance tolerance correction value}$

Example:

- 2.38 mm Wills Rings® O with 1 layer of plating
 $d_g = d_i - (2 \times 1 \text{ layer coating} = 2 \times 0.035 \text{ mm} = 0.070 \text{ mm}) - \text{clearance} (- \text{tol.})$
 $= d_i - 0.070 - \text{clearance} (- \text{tol.})$
 $= d_i - 0.070 - 0.18 (-0.12)$
 $= d_i - 0.37 \text{ mm}$

**WILLS RINGS® O FOR EXTERNAL PRESSURE**

These are typical of seal part numbers that can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the ordering example on page 26 and the seal data. See also page 8 and page 9, Table 2 to Table 4.

Table 14: Preferred Sizes Wills Rings® O, Metric

Seal Diameter	Seal Non-plated	Groove ID	Seal 1 Layer	Groove ID	Minimum Groove Width b_4	Groove Depth h
		$\varnothing d_g$ h_9		$\varnothing d_g$ h_9		
15	MOT A R0150-1_	11.67	MOT A R0150-1_R	11.60	2.25	1.32/1.40
20	MOT A R0200-1_	16.67	MOT A R0200-1_R	16.60	2.25	1.32/1.40
25	MOT A R0250-1_	21.67	MOT A G0250-1_R	21.60	2.25	1.32/1.40
30	MOT B R0300-1_	24.94	MOT B R0300-1_R	24.87	3.00	1.83/1.91
35	MOT B R0350-1_	29.94	MOT B R0350-1_R	29.87	3.00	1.83/1.91
40	MOT B R0400-1_	34.94	MOT B R0400-1_R	35.87	3.00	1.83/1.91
45	MOT B R0450-1_	39.94	MOT B R0450-1_R	39.87	3.00	1.83/1.91
50	MOT B R0500-1_	44.94	MOT B R0500-1_R	45.87	3.00	1.83/1.91
55	MOT B R0550-1_	49.94	MOT B R0550-1_R	49.87	3.00	1.83/1.91
60	MOT B R0600-1_	54.94	MOT B R0600-1_R	54.87	3.00	1.83/1.91
65	MOT C R0650-1_	58.34	MOT C R0650-1_R	58.27	4.00	2.54/2.67
70	MOT C R0700-1_	63.34	MOT C R0700-1_R	63.27	4.00	2.54/2.67
75	MOT C R0750-1_	68.34	MOT C R0750-1_R	68.27	4.00	2.54/2.67
80	MOT C R0800-1_	73.34	MOT C R0800-1_R	73.27	4.00	2.54/2.67
85	MOT C R0850-1_	78.34	MOT C R0850-1_R	78.27	4.00	2.54/2.67
90	MOT C R0900-1_	83.34	MOT C R0900-1_R	83.27	4.00	2.54/2.67
95	MOT C R0950-1_	88.34	MOT C R0950-1_R	88.27	4.00	2.54/2.67
100	MOT C R1000-1_	93.34	MOT C R1000-1_R	93.27	4.00	2.54/2.67
110	MOT D R1100-1_	101.76	MOT D R1100-1_R	101.69	5.00	3.05/3.18
120	MOT D R1200-1_	111.76	MOT D R1200-1_R	110.69	5.00	3.05/3.18
130	MOT D R1300-1_	121.76	MOT D R1300-1_R	120.69	5.00	3.05/3.18
140	MOT D R1400-1_	131.76	MOT D R1400-1_R	130.69	5.00	3.05/3.18
150	MOT D R1500-1_	141.76	MOT D R1500-1_R	140.69	5.00	3.05/3.18
160	MOT D R1600-1_	151.76	MOT D R1600-1_R	150.69	5.00	3.05/3.18
170	MOT E R1700-1_	160.11	MOT E R1700-1_R	160.04	6.00	3.68/3.81
180	MOT E R1800-1_	170.11	MOT E R1800-1_R	170.04	6.00	3.68/3.81
190	MOT E R1900-1_	180.11	MOT E R1900-1_R	180.04	6.00	3.68/3.81
200	MOT E R2000-1_	190.11	MOT E R2000-1_R	190.04	6.00	3.68/3.81
250	MOT E R2500-1_	240.11	MOT E R2500-1_R	240.04	6.00	3.68/3.81

Use this selection when designing a new housing/sealing system.

Also applies to Wills Rings® O for Type MOW.

Note:

These seal part numbers use ring sizing (indicated by "R" in the \varnothing code) and the groove $\varnothing d_g$. The seal diameter has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value, see Table 18 on page 25.



WILLS RINGS® C FOR EXTERNAL PRESSURE

These are typical of seal part numbers that can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the order example on page 27 and the seal data. See also page 8 and page 9, Table 2 to Table 4.

Table 15: Preferred Sizes Wills Rings® C, Metric

Seal Diameter	Seal Non-plated	Groove ID	Seal 1 Layer	Groove ID	Minimum Groove Width b_4	Groove Depth h
		$\emptyset d_g$ h9		$\emptyset d_g$ h9		
20	MCY A R0200-1_2	19.85	MCY A R0200-1_R2	19.78	2.25	1.32/1.40
25	MCY A R0250-1_2	24.85	MCY A R0250-1_R2	24.78	2.25	1.32/1.40
30	MCY A R0300-1_2	29.85	MCY A R0300-1_R2	29.78	2.25	1.32/1.40
35	MCY A R0350-1_2	34.85	MCY A R0350-1_R2	34.78	2.25	1.32/1.40
40	MCY A R0400-1_2	39.85	MCY A R0400-1_R2	39.78	2.25	1.32/1.40
50	MCY A R0500-1_2	49.85	MCY A R0500-1_R2	49.78	2.25	1.32/1.40
30	MCY B R0300-1_2	29.70	MCY B R0300-1_R2	29.63	3.00	1.83/1.91
40	MCY B R0400-1_2	39.70	MCY B R0400-1_R2	39.63	3.00	1.83/1.91
50	MCY B R0500-1_2	49.70	MCY B R0500-1_R2	49.63	3.00	1.83/1.91
60	MCY B R0600-1_2	59.70	MCY B R0600-1_R2	59.63	3.00	1.83/1.91
70	MCY B R0700-1_2	69.70	MCY B R0700-1_R2	69.63	3.00	1.83/1.91
80	MCY B R0800-1_2	79.70	MCY B R0800-1_R2	79.63	3.00	1.83/1.91
90	MCY B R0900-1_2	89.70	MCY B R0900-1_R2	89.63	3.00	1.83/1.91
70	MCY C R0700-1_2	69.70	MCY C R0700-1_R2	69.63	4.00	2.54/2.67
80	MCY C R0800-1_2	79.70	MCY C R0800-1_R2	79.63	4.00	2.54/2.67
90	MCY C R0900-1_2	89.70	MCY C R0900-1_R2	89.63	4.00	2.54/2.67
100	MCY C R1000-1_2	99.70	MCY C R1000-1_R2	99.63	4.00	2.54/2.67
110	MCY C R1100-1_2	109.70	MCY C R1100-1_R2	109.63	4.00	2.54/2.67
150	MCY C R1500-1_2	149.70	MCY C R1500-1_R2	149.63	4.00	2.54/2.67
110	MCY D R1100-1_2	109.70	MCY D R1100-1_R2	109.63	5.00	3.05/3.18
120	MCY D R1200-1_2	119.70	MCY D R1200-1_R2	119.63	5.00	3.05/3.18
130	MCY D R1300-1_2	129.70	MCY D R1300-1_R2	129.63	5.00	3.05/3.18
140	MCY D R1400-1_2	139.70	MCY D R1400-1_R2	139.63	5.00	3.05/3.18
150	MCY D R1500-1_2	149.70	MCY D R1500-1_R2	149.63	5.00	3.05/3.18
160	MCY D R1600-1_2	159.70	MCY D R1600-1_R2	159.63	5.00	3.05/3.18
160	MCY E R1600-1_2	159.63	MCY E R1600-1_R2	159.56	6.00	3.68/3.81
170	MCY E R1700-1_2	169.63	MCY E R1700-1_R2	169.56	6.00	3.68/3.81
180	MCY E R1800-1_2	179.63	MCY E R1800-1_R2	179.56	6.00	3.68/3.81
190	MCY E R1900-1_2	189.63	MCY E R1900-1_R2	189.56	6.00	3.68/3.81
200	MCY E R2000-1_2	199.63	MCY E R2000-1_R2	199.56	6.00	3.68/3.81
160	MCY P R1600-1_2	159.63	MCY P R1600-1_R2	159.56	8.00	5.08/5.21
170	MCY P R1700-1_2	169.63	MCY P R1700-1_R2	169.56	8.00	5.08/5.21
180	MCY P R1800-1_2	179.63	MCY P R1800-1_R2	179.56	8.00	5.08/5.21
190	MCY P R1900-1_2	189.63	MCY P R1900-1_R2	189.56	8.00	5.08/5.21
200	MCY P R2000-1_2	199.63	MCY P R2000-1_R2	199.56	8.00	5.08/5.21

Use this selection when designing a new housing/sealing system.

Note:

These seal part numbers use ring sizing (indicated by "R" in the \emptyset code) and the groove $\emptyset d_g$. The seal diameter has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value, see Table 18 on page 25.



■ Metric Part Numbers and Ordering Instructions

METRIC SIZE RANGES AND FREE HEIGHTS

Wills Rings® are available in a comprehensive range of sizes. Free height ranges from 1.59 mm to 6.35 mm and for each size there is a range of seal diameters which can be produced. Free height sizes are to industry standards and have evolved from inch sizes. See Table 16 and Table 17.

Table 16: Diameter Size Range for Wills Rings® O

Free Height d ₂ mm	Wall Code	Wall Thick-ness mm	Seal Ø d _a mm	Total Groove Depth ¹⁾ h mm	Groove Width ²⁾ b ₄ min. mm	
1.59	A	0.36	12-150	1.32	+0.08 -0	2.25
	K	0.25				
2.38	B	0.46	25-500	1.83	+0.08 -0	3.00
	L	0.25	50-500			
3.18	C	0.51	60-1000	2.54	+0.13 -0	4.00
	M	0.25				
3.97	D	0.64	100-1250	3.05	+0.13 -0	5.00
	N	0.25				
4.76	E	0.81	115-1500	3.68	+0.13 -0	6.00
	O	0.25	150-1500			
6.35	F	1.02	125-2000	5.08	+0.13 -0	8.00
	P	0.51				

See page 28 for Size Ranges and Free Heights in Inches.

Table 17: Diameter Size Range for Wills Rings® C

Free Height d ₂ mm	Wall Code	Wall Thick-ness mm	Seal MCX Ø d _a , MCY Ø d _i mm	Total Groove Depth ¹⁾ h mm	Groove Width ²⁾ b ₄ min. mm	
1.59	A	0.25	20-150	1.32	+0.08 -0	2.25
	K	0.15				
2.38	B	0.38	25-300	1.83	+0.08 -0	3.00
	L	0.25				
3.18	C	0.51	50-300	2.54	+0.13 -0	4.00
	M	0.38				
3.97	D	0.61	60-300	3.05	+0.13 -0	5.00
	N	0.41				
4.76	E	0.76	95-300	3.68	+0.13 -0	6.00
	O	0.51				
6.35	-	-	115-300	5.08	+0.13 -0	8.00
	P	0.64				

Note:

- 1) When using a gasket in conjunction with Wills Rings®, the groove depth must be modified. Please refer to the section on groove design, and in particular on automotive groove design, on page 17, Figure 10, Figure 11 and Figure 12.
- 2) Groove width given in Table 16 and Table 17 is the minimum. Ideally the groove width b₄ = 1.5 x d₂.



METRIC GROOVE CLEARANCE AND PLATING ALLOWANCES

The table below gives guidance on how to size a seal for a given groove diameter. This will enable sizing of seals correctly for a given groove diameter, or vice versa.

Table 18: Clearance - Tolerance Correction Value in mm

			No Plating		One Layer		Two Layers		Three Layers	
Maximum Plating			0.00		+ 0.035		+ 0.060		+ 0.085	
2 x maximum Plating			0.00		+ 0.070		+ 0.120		+ 0.170	
Free Height										
mm	code			Total		Total		Total		Total
1.59	A	K	0.10+0.05	0.15	0.17+0.05	0.22	0.22+0.05	0.27	0.27+0.05	0.32
2.38	B	L	0.18+0.12	0.30	0.25+0.12	0.37	0.30+0.12	0.42	0.35+0.12	0.47
3.18	C	M	0.18+0.12		0.25+0.12		0.30+0.12		0.35+0.12	
3.97	D	N	0.18+0.12		0.25+0.12		0.30+0.12		0.35+0.12	
4.76	E	O	0.25+0.12	0.37	0.32+0.12	0.44	0.37+0.12	0.49	0.42+0.12	0.54
6.35	F	P	0.25+0.12		0.32+0.12		0.37+0.12		0.42+0.12	

Wills Rings® clearance and tolerance correction values (CTCV) for different plating levels for each free height size.

See page 29 for Clearance Tolerance Correction Values in Inches.

Internal pressure $\varnothing d_7 = \varnothing d_a + \text{CTCV}$

External pressure $\varnothing d_8 = \varnothing d_i - \text{CTCV}$

Note:

Use $\varnothing d_a$ for Wills Rings® O for external pressure.

Use $\varnothing d_i$ for Wills Rings® C for external pressure.

For example

MOTOG1500K1HS

This is a 4.76 mm gas-filled Wills Rings® O thin wall seal for a 150.0 mm groove diameter d_7 . It has silver plate at 3 layers, 0.075/0.085 mm thickness.

The seal diameter is found from $\varnothing d_7 = \varnothing d_a + \text{CTCV}$

$$\begin{aligned} \text{Hence } \varnothing d_a &= \varnothing d_7 - \text{CTCV} \\ &= 150.0 - 0.54 \\ \varnothing d_a &= 149.46 \text{ mm} \end{aligned}$$



METRIC PART NUMBER SYSTEMS FOR WILLS RINGS®

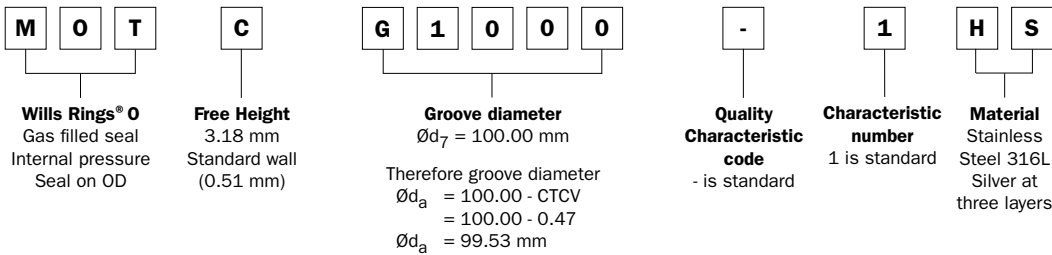
Table 19: Metric Part Number System for Wills Rings® O in Metric

Seal Type	Series	Free Height/ Wall Size mm	Seal Diameter	Quality Characteristic Code	Characteristic Number	Seal Material	Coating Material	
M O M Metal O O-Ring profile	T Gas- filled	Standard wall	Diameter x 10 (up to 999.9)	“-” Standard Quality	1 = Standard	H Stainless Steel AISI 316L (1.4435)	Q Nickel	
		A 1.59 0.36	G - - - - this is the groove outside diameter Ød ₇ x 10					
		B 2.38 0.46						
		C 3.18 0.51						
		D 3.97 0.64						
		E 4.76 0.81						
	F 6.35 1.02							
	V Pressure vented ID	W Pressure vented OD	Thin wall	Use the groove method only for internal pressure/ external sealing	“K” X-Ray required	E Stainless Steel AISI 321 (1.4541)	M Inconel® 600	U Silver Two layers
			K 1.59 0.25	R - - - - this is the ring outside dia. Ød _a x 10				
			L 2.38 0.25					
			M 3.18 0.25					
			N 3.97 0.25					
			O 4.76 0.25					
			P 6.35 0.51					

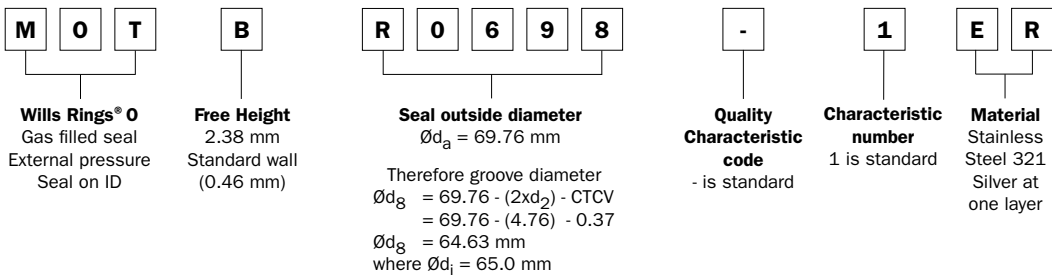
Notes:

Select Quality Characteristic Code K for thin wall rings.

ORDERING EXAMPLE 1



ORDERING EXAMPLE 2



See page 30 for part number system in Inches.



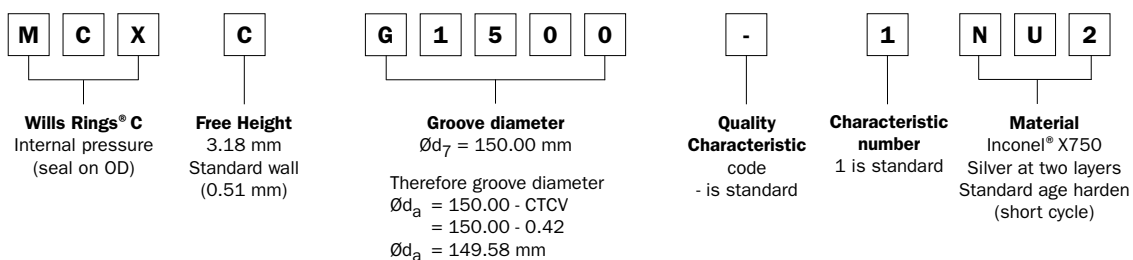
Table 20: Metric Part Number System for Wills Rings® C

Seal Type	Series	Free Height/ Wall Size mm	Seal Diameter	Quality Characteristic Code	Characteristic Number	Seal Material	Coating Material	Treatment	
M C M Metal C C-Ring profile	X Internal pressure	Standard wall	Diameter x 10 (up to 999.9) G - - - - this is the groove diameter ($\varnothing d_7$ or $\varnothing d_8$) x10	“-” Standard Quality	1 = Standard	L Inconel® 718	R Silver One layer	1 = Work hardened	
		A 1.59 0.25	“A” Aerospace use					2 = Standard age hardened (short cycle)	
		B 2.38 0.38						3 = Age hardened (long cycle)	
		C 3.18 0.51						R - - - - this is the ring diameter ($\varnothing d_a$ or $\varnothing d_i$) x 10	4 = Solution annealed and age hardened
		D 3.97 0.61						5 = Heat treatment to NACE MR0175	
		E 4.76 0.76							
	Y External pressure	Thin wall	Use outside diameter for internal pressure/ outside sealing				N Inconel® X750	S Silver Three layers	
		K 1.59 0.15							
		L 2.38 0.25							
		M 3.18 0.38							
		N 3.97 0.41							
		O 4.76 0.51							
P 6.35 0.64		Use inside diameter for external pressure/ inside sealing							

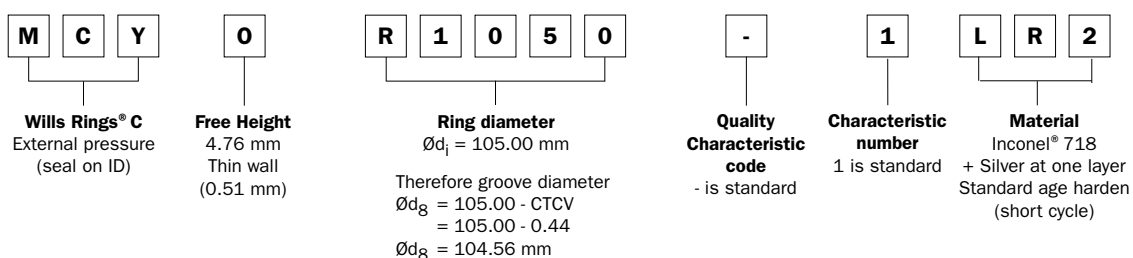
Notes:

Treatment code 5 for seal material Inconel® 718 only.

ORDERING EXAMPLE 1



ORDERING EXAMPLE 2



See page 31 for part number system in Inches.



■ Inch Part Numbers and Ordering Instructions

INCH SIZE RANGES AND FREE HEIGHTS

Table 21: Diameter Size Range in Inches for Wills Rings® O

Free Height d ₂ inch	Wall Code	Wall inch	Seal Ø d _a inch	Total Groove Depth ¹⁾ h inch	Groove Width ²⁾ b ₄ min. inch	
0.063	A	0.014	0.5-6	0.052	+0.003 -0	0.089
	K	0.010				
0.094	B	0.018	1-20	0.072	+0.003 -0	0.118
	L	0.010	2-20			
0.125	C	0.020	2.5-40	0.100	+0.005 -0	0.157
	M	0.010				
0.156	D	0.025	4-60	0.120	+0.005 -0	0.197
	N	0.010				
0.187	E	0.032	4.5-60	0.145	+0.005 -0	0.236
	O	0.010	6-60			
0.250	F	0.040	5-80	0.200	+0.005 -0	0.315
	P	0.020				

See page 24 for Size Ranges and Free Heights in Metric.

Wills Rings® are available in a comprehensive range of sizes. Free height ranges from 0.063 inch to 0.250 inch and for each size there is a range of seal diameters which can be produced. Free height sizes are industry standard and have evolved from inch sizes. See Table 21 and Table 22.

Table 22: Diameter Size Range in Inches for Wills Rings® C

Free Height d ₂ inch	Wall Code	Wall inch	Seal MCX Ø d _a , MCY Ø d _i inch	Total Groove Depth ¹⁾ h inch	Groove Width ²⁾ b ₄ min. inch	
0.063	A	0.010	0.8-6	0.052	+0.003 -0	0.089
	K	0.006				
0.094	B	0.015	1-	0.072	+0.003 -0	0.118
	L	0.010	11.81			
0.125	C	0.020	2-	0.100	+0.005 -0	0.157
	M	0.015	11.81			
0.156	D	0.024	2.4-	0.120	+0.005 -0	0.197
	N	0.016	11.81			
0.187	E	0.030	3.75-	0.145	+0.005 -0	0.236
	O	0.020	11.81			
0.250	-	-	4.5-	0.200	+0.005 -0	0.315
	P	0.025	11.81			

Note:

- 1) When using a gasket in conjunction with Wills Rings®, the groove depth must be modified. Please refer to the section on groove design, and in particular on automotive groove design on page 17, Figure 10, Figure 11 and Figure 12.
- 2) Groove width given in Table 21 and Table 22 is the minimum. Ideally the groove width b₄ = 1.5 x d₂.



INCH GROOVE CLEARANCE AND PLATING ALLOWANCES

The table below gives guidance on how to size a ring for a given groove diameter. This will enable sizing of seals correctly for a given groove diameter, or vice versa.

Table 23: Inch Clearance - Tolerance Correction Value

			No Plating		One Layer		Two Layers		Three Layers	
Maximum Plating			0.00		+ 0.0015		+ 0.0025		+ 0.0035	
2 x maximum Plating			0.00		+ 0.003		+ 0.005		+ 0.007	
Free Height										
inch	code			Total		Total		Total		Total
0.063	A	K	0.004+0.002	0.006	0.007+0.002	0.009	0.009+0.002	0.011	0.011+0.002	0.013
0.094	B	L	0.007+0.005	0.012	0.010+0.005	0.015	0.012+0.005	0.017	0.014+0.005	0.019
0.125	C	M	0.007+0.005		0.010+0.005		0.012+0.005		0.014+0.005	
0.156	D	N	0.007+0.005		0.010+0.005		0.012+0.005		0.014+0.005	
0.187	E	O	0.010+0.005	0.015	0.013+0.005	0.018	0.015+0.005	0.020	0.017+0.005	0.022
0.250	F	P	0.010+0.005		0.013+0.005		0.015+0.005		0.017+0.005	

Wills Rings® clearance and tolerance correction values (CTCV) for different plating levels for each free height size in Inches.

See page 25 for Clearance Tolerance Correction Values in Metric.

Internal pressure $\varnothing d_7 = \varnothing d_a + \text{CTCV}$

External pressure $\varnothing d_8 = \varnothing d_i - \text{CTCV}$

Note:

Use $\varnothing d_a$ for Wills Rings® O for external pressure.
Use $\varnothing d_i$ for Wills Rings® C for external pressure.

For example:

MOTOL1000K1HS

This is a 0.187 inch gas-filled Wills Rings® O thin wall seal for a 10.00 inch ring diameter d_a . It has silver plate at 3 layers, 0.003 inch/0.0035 inch thickness.

The groove diameter is found from $\varnothing d_7 = \varnothing d_a + \text{CTCV}$

$$\begin{aligned} \text{Hence } \varnothing d_7 &= \varnothing d_a + \text{CTCV} \\ &= 10.00 + 0.022 \\ \varnothing d_7 &= 10.022 \text{ inch} \end{aligned}$$



INCH PART NUMBER SYSTEMS FOR WILLS RINGS®

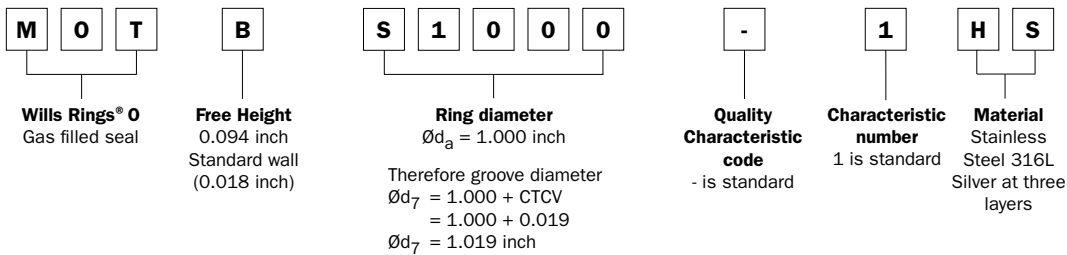
Table 24: Inch Part Number System for Wills Rings® O

Seal Type	Series	Free Height/ Wall Size	Seal Diameter	Quality Characteristic Code	Characteristic Number	Seal Material	Coating Material
M O M Metal O O-Ring profile	T Gas- filled V Pressure vented ID W Pressure vented OD	Standard wall	For small diameter up to 9.999 inch use S - - - - this is the ring outside diameter $\varnothing d_a$ to three decimal places	“-” Standard Quality “K” X-Ray required “A” Aerospace use	1 = Standard	H Stainless Steel AISI 316L (1.4435) E Stainless Steel AISI 321 (1.4541) M Inconel® 600	Q Nickel R Silver 1 layer U Silver 2 layers S Silver 3 layers
		A .063 .014	For larger diameter above 10.000 inch use L - - - - this is the ring outside diameter $\varnothing d_a$ to two decimal places				
		B .094 .018					
		C .125 .020					
		D .156 .025					
		E .187 .032					
	F .250 .040						
	K .063 .010						
	L .094 .010						
	M .125 .010						
	N .156 .010						
	O .187 .010						
	P .250 .020						

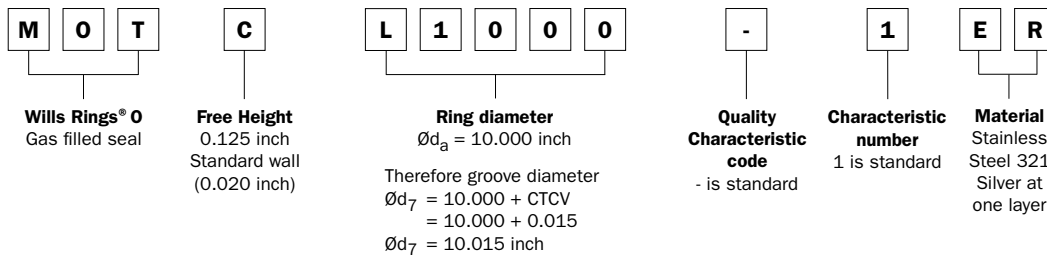
Notes:

Select Quality Characteristic Code K for thin wall rings.

ORDERING EXAMPLE 1



ORDERING EXAMPLE 2



See page 26 for part number system in Metric.



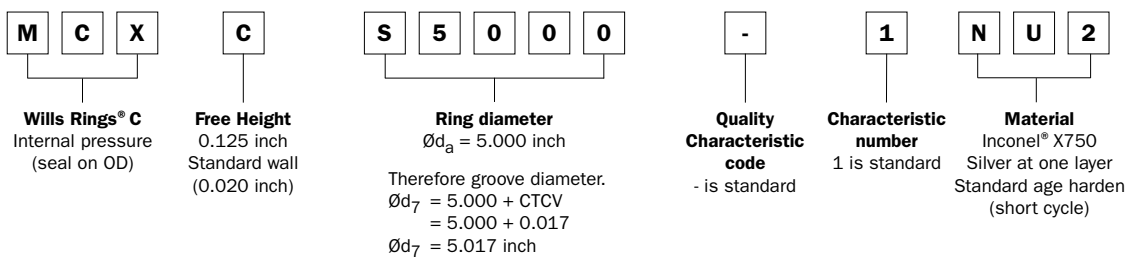
Table 25: Inch Part Number System for Wills Rings® C

Seal Type	Series	Free Height/ Wall Size	Seal Diameter	Quality Characteristic Code	Characteristic Number	Seal Material	Coating Material	Treatment				
M C M Metal C C-Ring profile	X Internal pressure	Standard wall	For small diameter up to 9.999 inch use S - - - - this is the ring outside diameter $\varnothing d_a$ to 3 places	“-” Standard Quality “A” Aerospace use	1 = Standard	L Inconel® 718 N Inconel® X750	R Silver One layer U Silver Two layers S Silver Three layers	1 = Work hardened				
		A .063 .010						2 = Standard age hardened (short cycle)				
		B .094 .015						3 = Age hardened (long cycle)				
		C .125 .020	For larger diameter above 10.000 inch use L - - - - this is the ring outside diameter $\varnothing d_a$ to two decimal places					4 = Solution annealed and age hardened				
		D .156 .024						5 = Heat treatment to NACE MRO175				
	Y External pressure	Thin wall	Use outside diameter for internal pressure/ outside sealing									
		K .063 .006										
		L .094 .010										
		M .125 .015										
		N .156 .016										
O .187 .020												
P .250 .025	Use inside diameter for external pressure/ inside sealing											

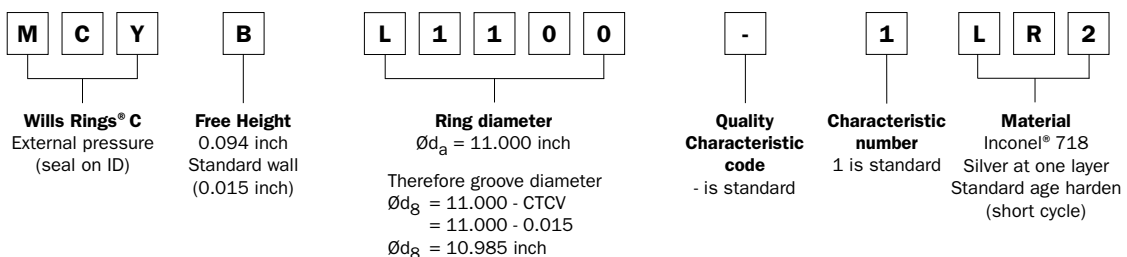
Notes:

Treatment code 5 for seal material Inconel® 718 only.

ORDERING EXAMPLE 1



ORDERING EXAMPLE 2



See page 27 for part number system in Metric.



■ Quality Criteria

The cost-effective use of seals and bearings is highly influenced by the quality criteria set for production. Seals and bearings manufactured by Trelleborg Sealing Solutions are continuously monitored according to strict quality standards from material acquisition through to delivery.

Our quality policy is consistently controlled by strict procedures and guidelines which are implemented within all areas of the company.

Production facilities are certified according to relevant quality management system standards. Depending on the requirements of the customer or market and in addition to the current ISO 9001, these locations may have further certifications: IATF 16949 for Automotive customers, EN/AS 9100 for Aerospace customers, ISO 13485 for Healthcare & Medical customers and ISO 29001 for Oil & Gas customers. This enables us to provide all market segments with the required quality standards.

All testing of materials and products is performed in accordance with accepted test standards and specifications. Inspection specifications correspond to standards applicable to individual product groups. The tenth digit of our part number defines the quality characteristics of the part. A hyphen indicates compliance with standard quality criteria outlined in this catalog.

Customer-specific requirements are indicated by a different symbol in this position. Customers who require special quality criteria should contact their local Customer Solution Center for assistance. We have experience in meeting all types of customer quality requirements.

■ Storage

Seals and bearings are often stored as spare parts for prolonged periods. With a few simple precautions, the shelf life of these products can be considerably lengthened.

Seals and bearings should be stored where they are safe from damage by external influences. Deformation, in particular, should be avoided.

The properties of certain materials may change under the influence of various external factors e.g. heat, moisture, light, oxygen, ozone and as a result of contact with liquid media.

The following guidelines should be observed to maintain the optimum physical and chemical properties of the parts:

HEAT

The ideal temperature for storage is between +5° C / +41° F and +25° C / +77° F. Direct contact with heaters should be avoided.

MOISTURE

Parts may be stored dry under normal atmospheric conditions (65 percent rel. moisture ± 10).

WEATHERING

To protect them against damage, seals and bearings should be kept in the original sealed packaging.

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Design Support & Engineering Tools

ONLINE TOOLS MAKE LIFE EASIER

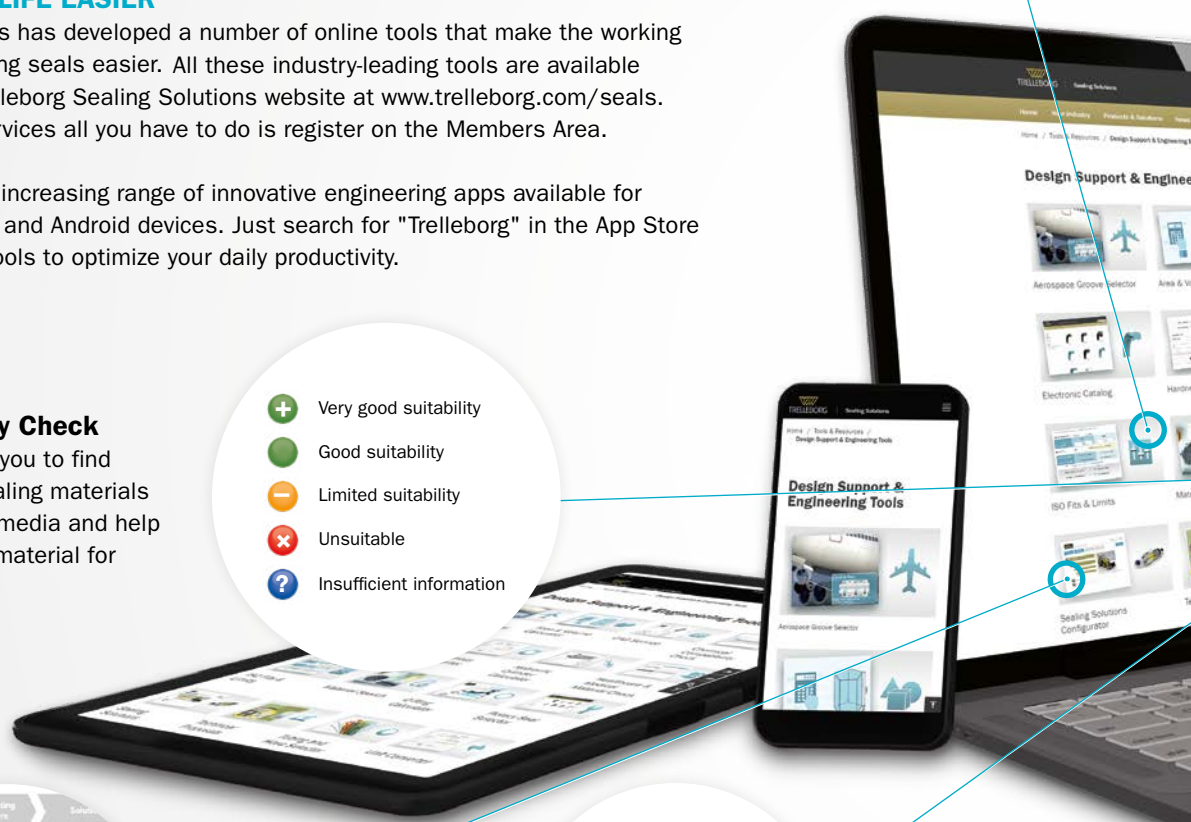
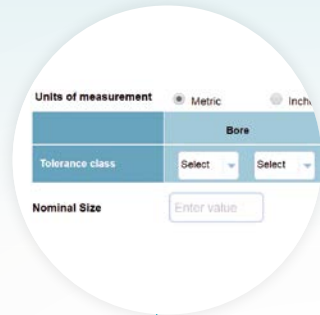
Trelleborg Sealing Solutions has developed a number of online tools that make the working life of an engineer specifying seals easier. All these industry-leading tools are available free-of-charge from the Trelleborg Sealing Solutions website at www.trelleborg.com/seals. To use these advanced services all you have to do is register on the Members Area.

There is also a continually increasing range of innovative engineering apps available for smartphones, both for iOS and Android devices. Just search for "Trelleborg" in the App Store or GooglePlay to find the tools to optimize your daily productivity.

Materials Search and Chemical Compatibility Check

These two programs allow you to find out the compatibility of sealing materials with hundreds of different media and help identify the most suitable material for your application.

- + Very good suitability
- Good suitability
- Limited suitability
- ✗ Unsuitable
- ? Insufficient information



Sealing Solutions Configurator

The Sealing Solutions Configurator is the first tool of its kind offered by any seal supplier. It allows engineers to identify a proven sealing solution for their specific application in just four easy steps.

4.0 Proposal Introduction

Dear Hilde Heens
Thank you for your call. We have had a look sealing solution to your application.

7.1.3 TSS Item No. and installation dimens

1. Turcite® / Zurcon® GR6901000-T47

Stydring®
Rod Diameter dN=100.0
Groove Diameter D2=105.0
Groove Width LZ=9.7

Stydring® GR73A1000-CY
Rod Diameter dN=100.0
Groove Diameter D2=105.0

Technical Proposals Online

Enhance your communication with Trelleborg Sealing Solutions with the Technical Proposals Online tool. Instantly access all your proposed solutions anywhere at any time and benefit from quicker dialog with our sealing specialists.



ISO Fits & Tolerances

Our Fits & Tolerances Calculator allows you to easily determine type of fits using the tolerances according to DIN ISO 286. In addition, upon entering the nominal diameter the tool calculates lower and upper limit deviations plus the maximum and minimum interferences dependent on the selected tolerance classes for bore and shaft.



Versatile CAD Service

The CAD download functionality provides thousands of drawings of a wide range of seals. It gives the option of 2- or 3-dimensional files in a range of formats to suit most commonly used CAD systems.



Hydraulic System Calculator

Hydraulic System Calculator helps you design a solution around the cylinder which may involve motor, pump, orifice and pipe calculations. The application is in compliance with ISO 3320, ISO 3321 & ISO 4393.



Rotary Seal Selector

The Rotary Seal Selector allows you to search through the wide range of rotary seals and materials available based on application conditions and offers detailed information on installation and seal capabilities.



O-Ring Calculator

An industry-leading tool, the easy to use O-Ring calculator includes sizing capabilities, compression forces, design parameter recommendations and complete measurements. Results and comments may be printed, shared or filed as PDF.

Discover our design support and engineering tools at www.trelleborg.com/seals



Mobile Tools & Apps

We understand the needs of engineers on the go. Check out our latest mobile tools and apps, ranging from an O-Ring calculator to unit and hardness converters. Just search for "Trelleborg" in the App Store or Google Play to find the tools to optimize your daily productivity.

Discover our wide range of mobile tools and apps at www.trelleborg.com/seals

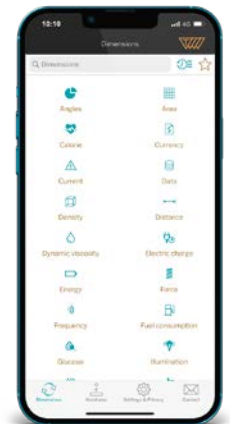
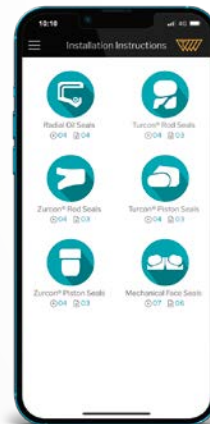
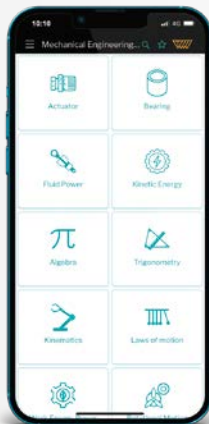


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ISO Fits & Tolerances

Simply enter the nominal diameter and select the tolerance classes for bore and shaft to find the complete ISO fits definition. It contains all relevant values, including type of fit, with handy graphs to illustrate the classes by bore and shaft. The results of this application are based on DIN ISO 286.



Mechanical Engineering Calculator

A useful app containing over 250 formula calculators in 16 categories, with more being added with every update. Categories include the fields of mathematics, physics and mechanical engineering.



Aerospace Groove Selector

This app covers five of the most important SAE Aerospace groove standards, making it quick and easy to find the size of grooves and hardware needed. Includes dimensions for AS4716 Rev B, AS5857 Rev A, AS6235 Rev A, AS4088 Rev E and AS4832 Rev A.



Installation Instructions

Videos demonstrate the best practice methods for installing seals, providing all relevant documentation within the interface. It guides you to successful installation of Radial Oil Seals, Mechanical Face Seals and Turcon® and Zurcon® rod and piston seals.



Converter - Universal

By simply selecting the dimension and entering a value for conversion, the app offers a wide range of engineering and scientific units for each dimension. It also has other useful features like currency conversion, timezone conversion, percentage calculations, a running pace calculator and more.



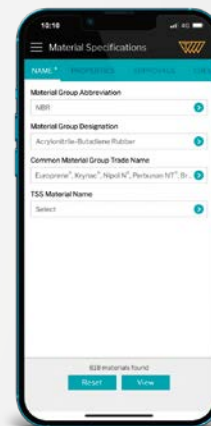
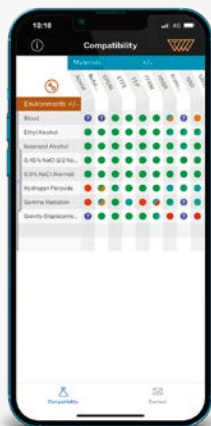
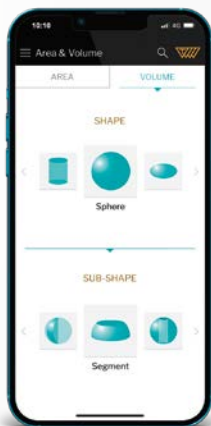
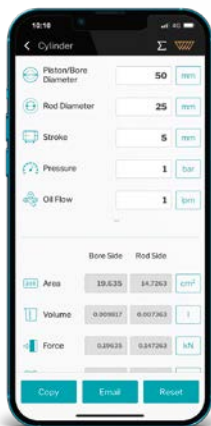
in the groove

Our *in the groove* magazine provides news, technical and product information on seals, as well as insights into the markets they are used in. The magazine is also available in print and as an interactive PDF.



Rotary Seal Selector

This app is specifically for the selection of rotary seals based on application information, including size, operating parameters and the lubricant used. It also considers installation type and seal function.



O-Ring Selector

When a user enters installation specifications into the O-Ring Selector app, such as the bore or rod/shaft diameter, the app quickly calculates O-Ring and housing dimensions in both metric and inch. Standards covered are ISO 3601-1, NFT 47-502, JIS B 2401 and SMS 1586.



Hydraulic System Calculator

The Hydraulic System Calculator helps you design a solution around the cylinder, which may involve motor, pump, orifice and pipe calculations. The application is in compliance with ISO 3320, ISO 3321 and ISO 4393.



Area and Volume Calculator

Speeds up and simplifies calculating the area and volume of more than 170 geometric shapes. The app supports both metric and inch, and conveniently displays the formulas used. Fill your shape with solids or liquids, choosing from 1500 different materials to calculate the weight.



Healthcare Materials

A quick and easy overview of the compatibility of 34 materials with 35 chemical environments that are commonly encountered in the healthcare and medical industries. Select up to 20 materials and environments at once to produce a chart that rates each material from 'excellent' to 'not recommended'.



Sealing Materials Selector

Enter material specifications and required parameters, such as application temperature or hardness, to receive instant material proposals. The app features filters to limit searches based on chemical compatibility, institute approvals and product type. Data sheets can be requested from within the interface.

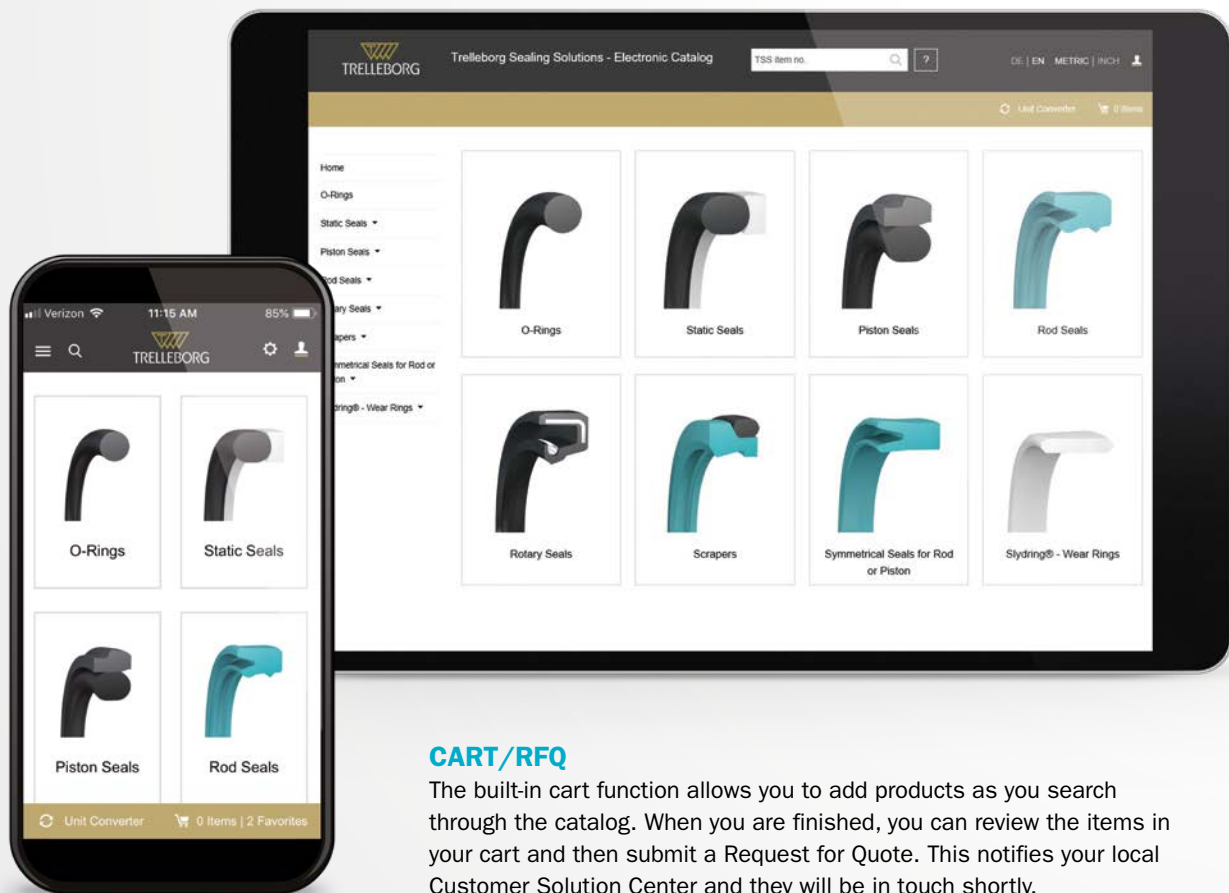
Electronic Catalog

Discover the Electronic Catalog online as an app or on our website



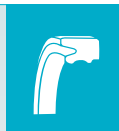
The Electronic Catalog is a user-friendly service that connects you to the broad range of products Trelleborg Sealing Solutions offers. The products are arranged based on product type and product group, making it easy to find the exact one you need.

Many functions are also included within the Electronic Catalog that allow you to understand product capabilities, compare similar seals, request a quote and much more. The Electronic Catalog is available from the Trelleborg Sealing Solutions website and in the App Store and GooglePlay for mobile use.



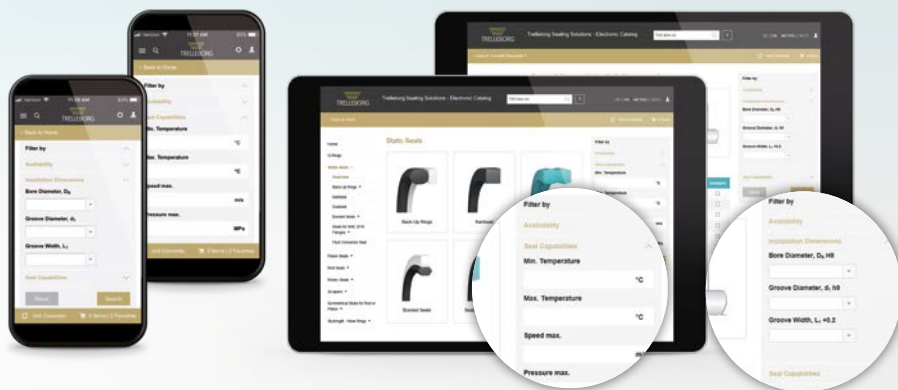
CART/RFQ

The built-in cart function allows you to add products as you search through the catalog. When you are finished, you can review the items in your cart and then submit a Request for Quote. This notifies your local Customer Solution Center and they will be in touch shortly.



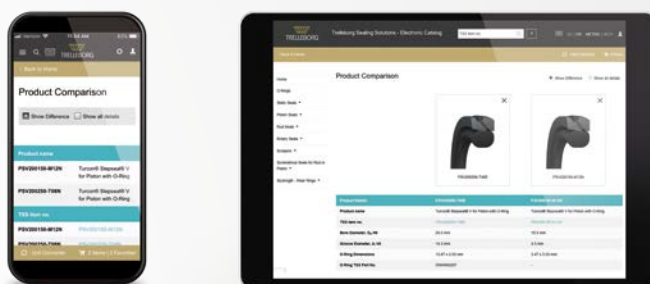
FILTERING

If you have specific operating conditions that the seal must meet and/or installation dimensions, the Electronic Catalog offers a filtering function within the product groups. Here you can input your temperatures, pressure, speed and various installation dimensions to filter products that can meet your needs.



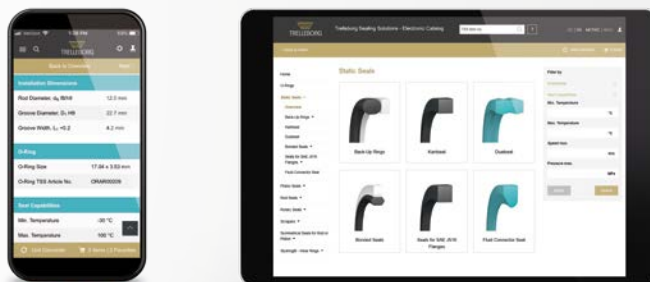
PRODUCT COMPARISON

When looking through the catalog, you can choose to compare multiple products. The product comparison function allows you to select which products you are interested in, and then puts all relevant information into a table for your review. You can even choose to display all product details side by side or to only show the fields where they differ.



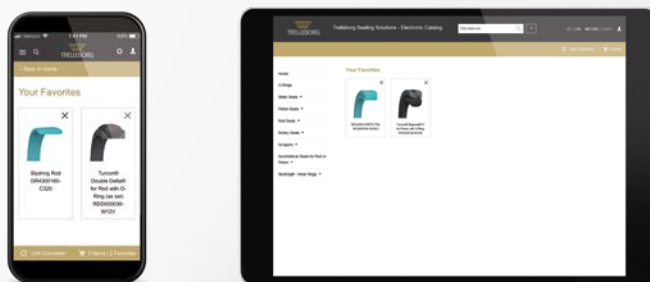
PRODUCT INFORMATION

Detailed product information is available for each part number. Once you select a specific part number, you will be able to see its installation dimensions, seal capabilities, related catalogs and other information. From this page, registered users can access the material data sheets that are applicable to the part number.



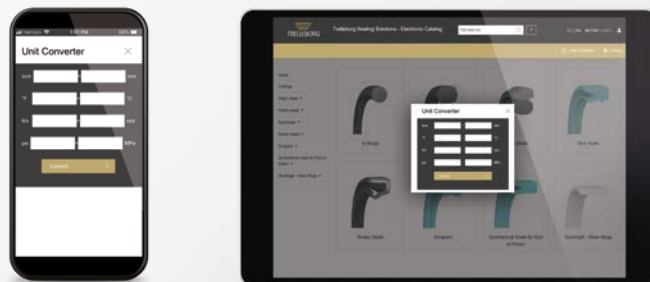
ADD TO FAVORITES

Do you have a part that you frequently look up or need information on? You can now save any of our part numbers as a favorite that is linked to your account. Anytime you log in to the Electronic Catalog, your favorites will be a click away!



UNIT CONVERTER

If you are looking at a product and need to know the conversion between metric and imperial, you can use the Unit Converter tool that is available at the top of the screen for web users and at the bottom for mobile.



Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way.

Trelleborg Sealing Solutions is a leading developer, manufacturer and supplier of precision seals, bearings and custom-molded polymer components. It focuses on meeting the most demanding needs of aerospace, automotive and general industrial customers with innovative solutions.

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