Contents

ISO 9001 ISO 9002

The information in this brochure is based on many decades of experience in the manufacture and application of sealing and bearing systems. However, unknown parameters and conditions may restrict general statements during usage. It is vital that customers satisfy themselves as to the suitability of individual products through adequate testing. For this reason, and due to the wide range of applications of our products, Busak+Shamban can accept no liability as to the suitability or correctness of our recommendations in individual cases.

The application limits for pressure, temperature and speed given in this catalogue are maximum values determined in the laboratory. During practical applications it should be remembered that due to the interaction of the operating parameters, the maximum values must be set correspondingly lower. For exceptional operating conditions, please contact your Busak+Shamban representative.

This edition supersedes all previous brochures.

Introduction

Busak+Shamban designs and manufactures a wide range of seals and bearings which are used in many industries and applications. Wills Rings® are metal seals which can be of two fundamental designs:

a) Wills Rings®O

b) Wills Rings®C

Wills Rings® are superior controlled compression type seals and are for static applications only. For best sealing results Wills Rings® should be replaced each time the groove housing is dismantled. Wills Rings® have a degree of elastic recovery after being compressed in a housing - but this is not sufficient to guarentee sealing again once the housing has been dismantled.

Wills Rings® are designed for extreme conditions which exceed the capabilities of elastomer and polymer seals.

Wills Rings®O are the original Metal O-Ring seals. Wills Rings® were developed at the Wills factory in Bridgwater, UK. The term 'Wills Rings' is often used internationally to describe Metal O-Ring seals.

Wills Rings®O consist of a tube formed into a circular profile. Wills Rings®C are similar, but they have 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.

Wills Rings® are constructed from high quality metal tubing or strip in standard or thin wall thickness, they are often coated or plated with a softer material to increase their sealing performance. There are five types of Wills Rings® depending upon the application (Figure 1).

Typical Applications:

- Nuclear power plant
- Furnaces
- Offshore and marine
- Cryogenics
- Extreme vacuum systems
- Fire safe valves
- Plastic processing
- Automotive

The design of Wills Rings® can be modified to suit the specific requirements of a system. These different designs offer a variety of sealing performances.

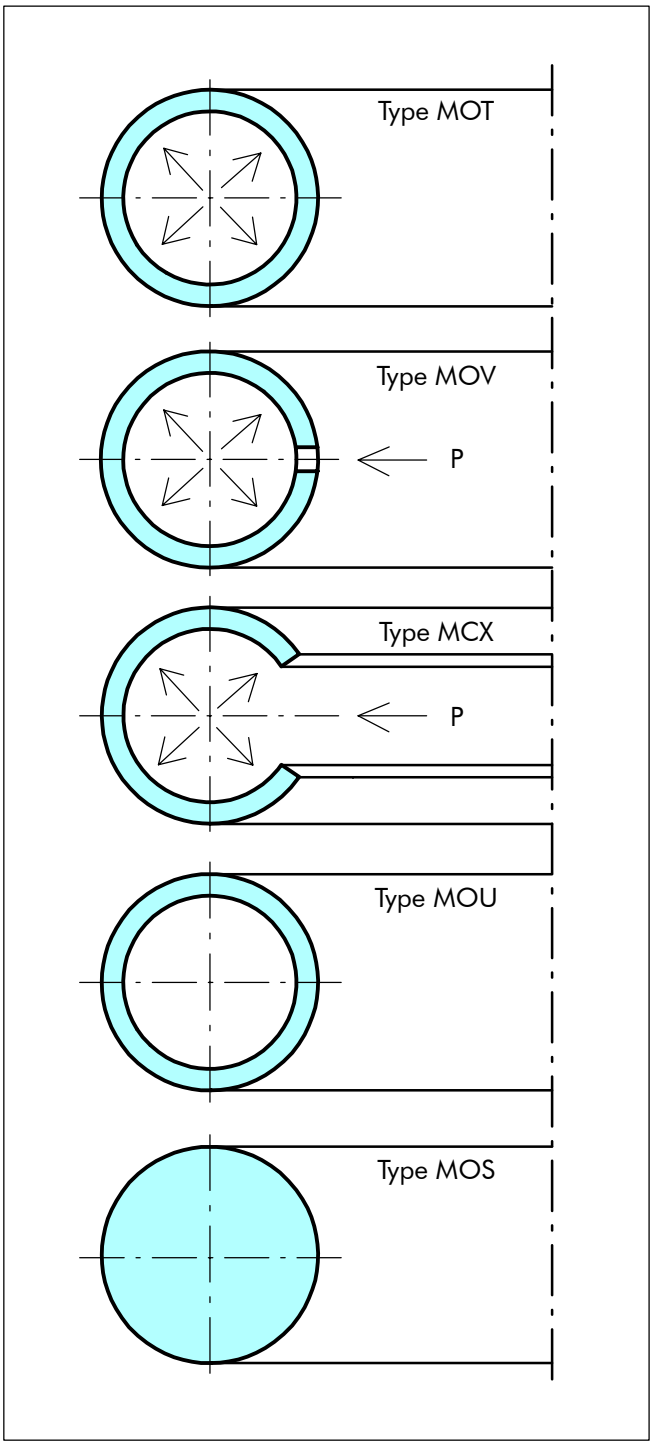


Figure 1 Wills Rings®

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 d2 of the seal is compressed down to the groove depth h. The resistance of the ring to compression enables it to form an effective seal when compressed. The resilient effect of the seal is increased by pressurising the internal volume of the ring (see Type MOT gas filled Wills Rings®O).

Alternatively, if the system to be sealed is of very high pressure - this can be used to provide additional sealing effect. This is termed 'system actuation'. This is achieved by allowing the high pressure to enter the seal through either vent holes (see Type MOV), or through the open C slot (see Type MCX, Figure 1).

Wills Rings® seals 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 influences the seal's ability to absorb or compensate for hardware variations due to temperature loadings, and thus maintain the seal integrity (Figure 2).

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

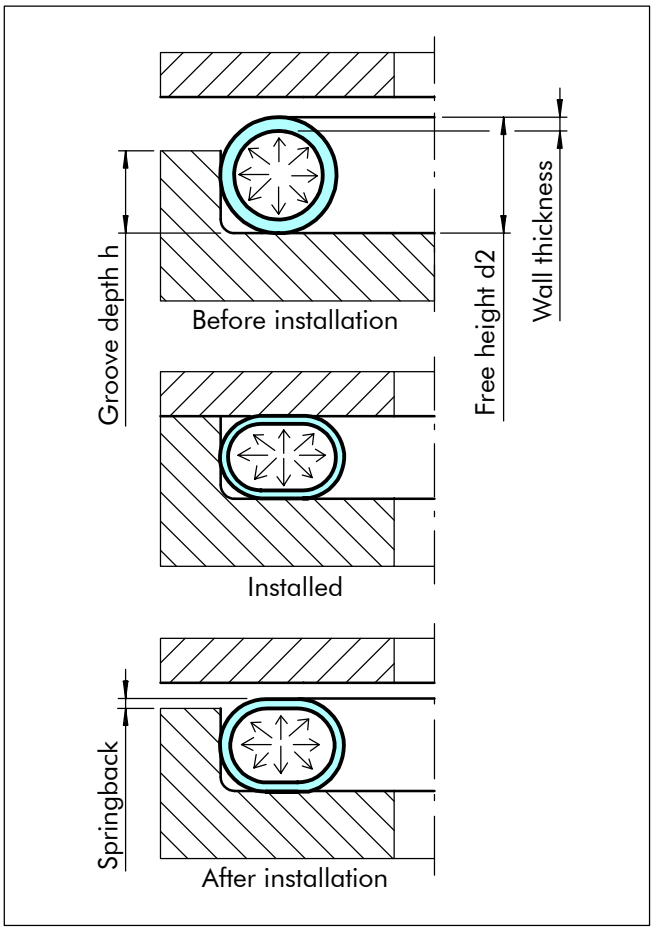


Figure 2 Method of seal operation

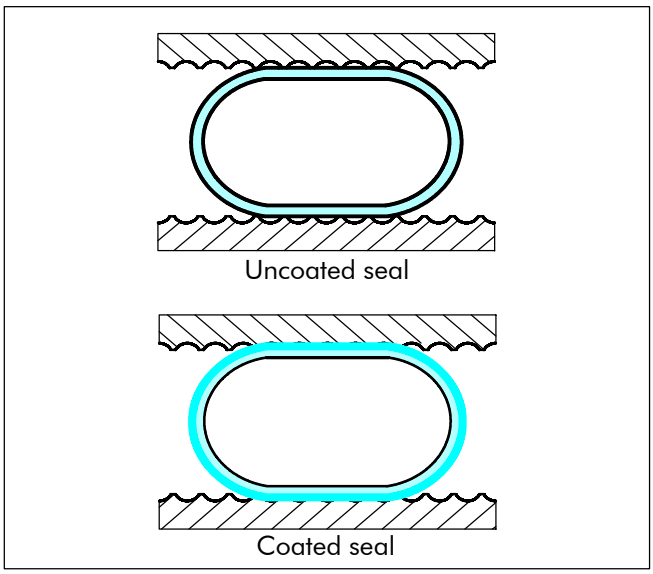


Figure 3 Contact surface for coated and uncoated Wills Rings®

Performance

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

Wills Rings® seals do not "out gas". Outgassing is normally associated with elastomer type seals. Although not a significant amount of gas is emitted, it can be a problem when a seal is used on sensitive equipment.

Advantages

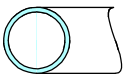
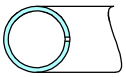
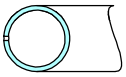
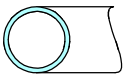
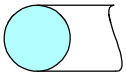
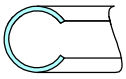
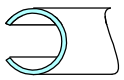
- Temperature range from cryogenic to 850°C/1550°F
- Pressure range from ultra high vacuum to 1000 MPa/145 000 psi
- Compatible with a large range of media
- Corrosion resistant and radiation tolerant
- Simple and reliable sealing
- No "out gassing"
- Wide range of sizes

Selection Table

Use this table to select the optimum seal for a given application. The scoring for each seal type indicates relative performance.

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

Table I Selection Criteria

Seal		Description	Extreme Conditions	Seating Loads	Page 17 Spring-back	Page 7 Vacuum Sealing	Page 7 Pressure MPa/psi	Page 6 Max. Working Temp. °C/°F	Page 6 Standard Material	
Code	Page		Note 1)	Note 2)	Note 3)	Note 4)		Cryogenic to	Seal Note 5)	Coating
Type MOT 	8	Pressurized	A	C	C	A	40 MPa 5800 psi	850°C 1550°F	Mild steel Stainless steel 316L 321 Inconel® 600 Copper	PTFE Silver Nickel
Type MOV 	8	Vented internal	B	B	C	C	1000 MPa 145 000 psi	600°C 1100°F		
Type MOW 	8	Vented external								
Type MOU 	9	Non-pressurized	C	B	C	C	4 MPa 580 psi	400°C 750°F		
Type MOS 	9	Solid	C	D	D	B	4 MPa 580 psi	500°C 925°F		
Type MCX 	11	Internal pressure	B	A	A	C	200 MPa 29 000 psi	750°C 1375°F	Inconel® 718 Inconel® X750	PTFE Silver
Type MCY 	11	External pressure								

Properties: A = Excellent B = Good C = Satisfactory D = Poor

If further information on seal selection is required please contact your local Busak+Shamban office.
Inconel® is a trade mark of INCO Alloys International, Inc.

Notes:

1) Extreme conditions could be radiation, searching gases, long life.

2) Thin wall material should be used to give low seating loads. This must be specified as seals are made in standard wall unless otherwise requested.

3) The elastic recovery of the seal is known as the 'Springback'. Springback depends upon wall thickness, and also heat treatment for Wills Rings® C. Higher seal resilience gives higher springback, and higher seating loads.

4) Ability to seal a hard vacuum to meet a leakage rate of $Q < 1 \times 10^{-9}$ mbar.l.s^{-1}

5 Other material options are available. Not all materials are available in all sizes! Not all coatings available for all materials. See temperature limitations (Table II).

Materials

Seal Base Material

Wills Rings® are used as static seals in a large number of industrial sectors as well as in aerospace. Wills Rings® are available in a wide range of materials. The choice of materials affects the seal performance in many ways. The material must be chosen after considering the following points:

Pressure and temperature
Seating loads
Corrosion resistance
Compatibility with housing materials
Life requirements
Sealing level required
Cost of seal

The more arduous the conditions, the better the seal material must be.

Table II Standard Seal Materials, for Wills Rings® O

Standard Material	Temperature		Code
	°C	°F	
Copper	400	750	O
Mild steel	550	1025	B
Stainless steel AISI 316L (1.4435)	800	1475	H
Stainless steel AISI 321 (1.4541)	800	1475	E
Inconel® 600	850	1550	M

Table III Standard Seal Materials, for Wills Rings® C

Standard Material	Temperature		Code
	°C	°F	
Inconel® X750	750	1375	N
Inconel® 718	750	1375	L

Please note:
Not all materials are available in all sizes.
Alternative materials and coatings can be offered.

Plating/Coating Materials for Wills Rings®

The sealing capability of Wills Rings® is greatly enhanced by the addition of a softer coating material (Figure 3)

Table IV gives the technical data for each coating, including the plating thickness, temperature capability and the size range.

Select plating/coating for a given application by considering the system requirements. That is:

1. The level of the sealing needed and the fluid to be sealed.
2. Will the temperature of the system affect the plating ?
3. Is the media corrosive to the plating ?
4. For higher levels of sealing, use more layers of plating combined with a better surface finish.
   Note: increased plating and a better surface finish make the seal and the hardware more expensive to produce.
5. For less critical applications - non-plated rings may provide sufficient sealing.

   Do not hesitate to contact our technical department for further information.

Table IV Standard Coating Materials

Coating		Coating-Thickness mm	Temperature		Comments	Max. Ø mm
Material	Code		°C	°F		
PTFE	W	0.030 ± 0.005	260	500	Not available on copper rings	2000
Nickel	Q	0.030 ± 0.005	1200	2200	-	1000
Silver	R	0.030 ± 0.005	800	1475	1 layer silver	1000
Silver	U	0.055 ± 0.005	800	1475	2 layers silver	1000
Silver	S	0.080 ± 0.005	800	1475	3 layers silver	1000

For non-plated rings please omit the plating code from the part number.

Hardware, Finish and Media

Table V shows the media which 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 the 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). Polishing can lead to radial marks on the sealing surface which may form leak paths.

Typically a thinner 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 should become.

Table V Media and Hardware Surface Finishes

Sealing System/Media	Ra μ m	Rmax μ m	Typical Coating	Comments
Ultra high vacuum	0.1 - 0.2	1.2 - 1.6	S	Use this for safety critical systems
Cryogenic - High vacuum	0.1 - 0.2	1.2 - 1.6	S	
Helium, Hydrogen	0.1 - 0.2	1.2 - 1.6	S	
Nitrogen, Steam	0.2 - 0.4	2.0 - 2.5	R/S/W/Q	-
Cryogenic - Light vacuum	0.2 - 0.4	2.0 - 2.5	R/S/W/Q	-
Air, Water, Light fuel	0.4 - 0.8	3.0 - 4.0	R/W/Q	Non-plated rings may be suitable
Heavy oils, Polymer	0.4 - 0.8	3.0 - 4.0	R/W/Q	

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 and chemical attack
- Resistant to radiation
- Long Life

Technical Data

Operating pressure:	Vacuum - helium tight 1 x 10^{-9} mbar.l.s^{-1}
High pressure:	up to 40 MPa/5800 psi
Temperature:	Cryogenic to 850°C/1550°F (constant temp.)
Seal type:	Internal and external sealing
Standard materials:	Stainless steel
Coating material:	Silver recommended

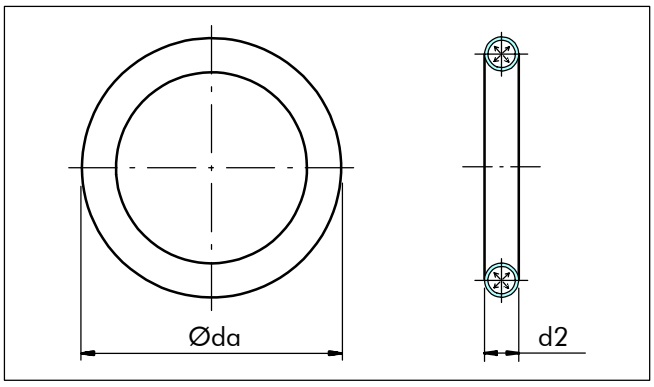


Figure 4 Wills Rings®O - Type MOT

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

These seals are ideal for extreme pressure applications. System pressure is allowed to actuate 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 (Type MOW).

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

Advantages

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

Technical Data

Operating Pressure:	High pressure: from 7 to 1000 MPa /1015 to 145 000 psi
Temperature:	Cryogenic to 600°C/1100°F (constant temp.)
Seal type:	Internal and external pressure sealing
Standard materials:	Stainless steel
Coating material:	Silver recommended

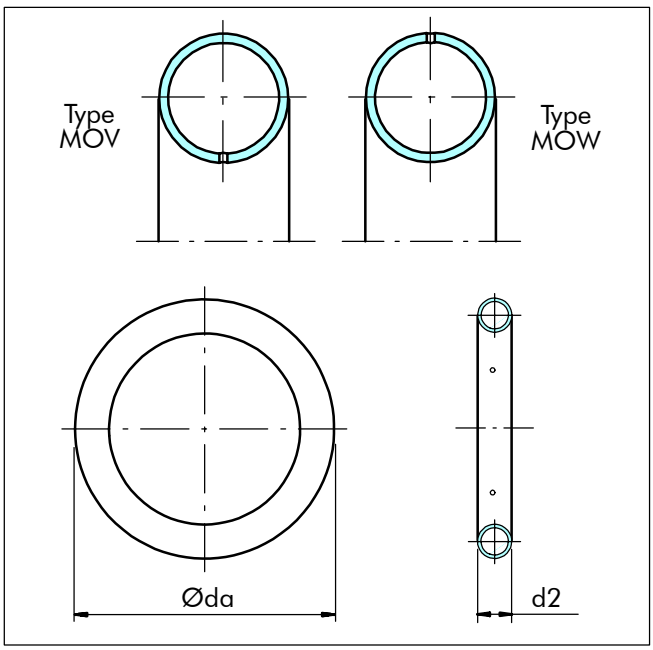


Figure 5 Wills Rings®O - Type MOV/MOW

Wills Rings®O Type MOU Non-Pressurised

These are Wills Rings®O seals for low sealing requirements. They have gas filling at atmospheric pressure only and this limits the safe maximum working temperature.

Advantages

- Available in a wide range of materials and finishes
- Resistant to corrosion and chemical attack
- Long Life
- Cost effective in less demanding applications

Technical Data

Operating pressure:	Vacuum - bubble tight 1 x 10^{-5} mbar.l.s^{-1} Pressure - up to 4 MPa/580 psi
Temperature:	Cryogenic to 400°C/750°F
Seal type:	Internal and external pressure sealing
Seal materials:	Stainless steel

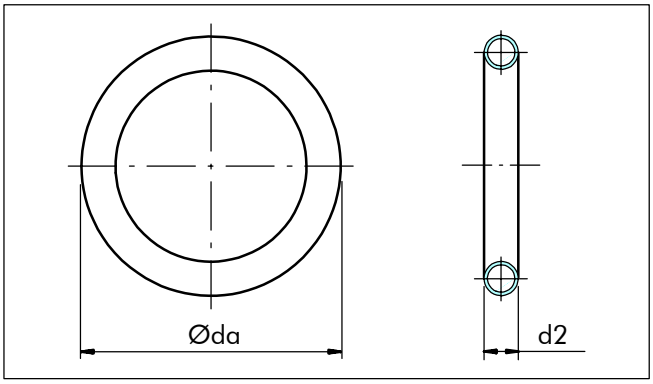


Figure 6 Wills Rings®O - Type MOU

Wills Rings®O Type MOS Solid

These are crush seals which operate in similar manner to gasket sealing. Solid seals exhibit virtually no elastic behaviour and also have very high seating loads.

Advantages

- Good vacuum sealing capability
- Available in a wide range of materials and finishes
- Resistant to corrosion and chemical attack
- Long Life
- Cost effective in less demanding applications

Technical Data

Operating pressure:	Vacuum - bubble tight 1 x 10^{-5} mbar.l.s^{-1} Pressure - up to 4 MPa/580 psi
Temperature:	Cryogenic to 500°C/925°F
Seal type:	Internal and external pressure sealing
Seal materials:	Stainless steel and copper

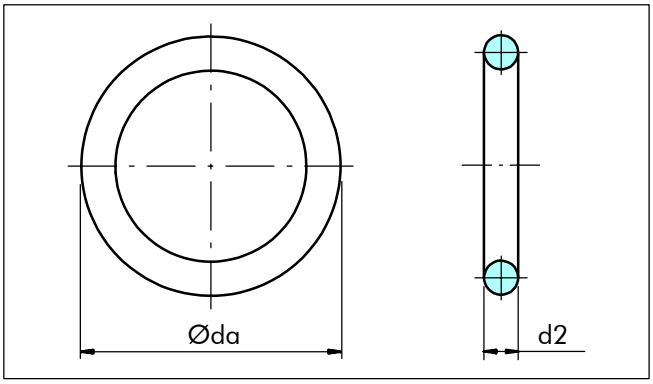


Figure 7 Wills Rings®O - Type MOS

Wills Rings®O Special Designs For Non-Circular Grooves

Wills Rings®O are also supplied in a variety of specially manufactured shapes to accommodate non-circular flanges and vessels. In the design of form seals the minimum bending radius in relation to the free height must be observed (Table VI). This is different to the minimum seal diameter for a given seal free height.

(Figure 8 examples of non-circular seals).

Table VI Minimum Bending Radius for Wills Rings®O

Free Height d2 [mm]	Min. Bending Radius [mm]
1.59	7
2.38	13
3.18	30
3.97	50
4.76	75
6.35	100
7.94	200
9.53	300

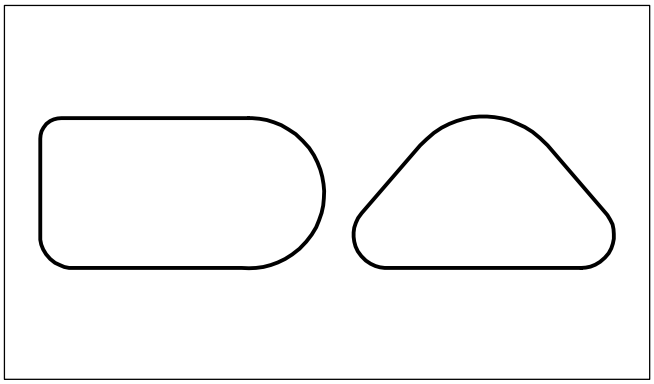


Figure 8 Examples of non-circular seals

For further information on special seal designs please contact your local Busak+Shamban office.

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

System pressure is allowed to actuate the seal through a vent slot in the C profile which runs around the entire circumference of the seal. This slot is internal for internal pressure, and external for external pressure.

Another benefit of this seal type is the increased amount of seal springback. This can be triple the amount exhibited by metal O-Ring seals.

Also, by using a thin wall section, low seating loads can be achieved for Wills Rings®C.

Advantages

- Low seating loads
- High springback
- Good pressure capability
- Good temperature capability
- Corrosion resistant
- Radiation resistant
- Long Life

Technical Data

Pressure:	Vacuum - bubble tight 1 x 10^{-5} mbar.l.s^{-1} to 200 MPa/29 000 psi
Temperature:	Cryogenic to 750°C/1375°F
Seal type:	Internal and external pressure sealing
Seal materials:	Inconel® X750 Inconel® 718
Coating materials:	Silver PTFE

Note:

For internal pressure,
Wills Rings®C Type MCX are sized to their outside diameter, ∅ da.

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

Hence, the Wills Rings®C is always sized to the back of the C profile.

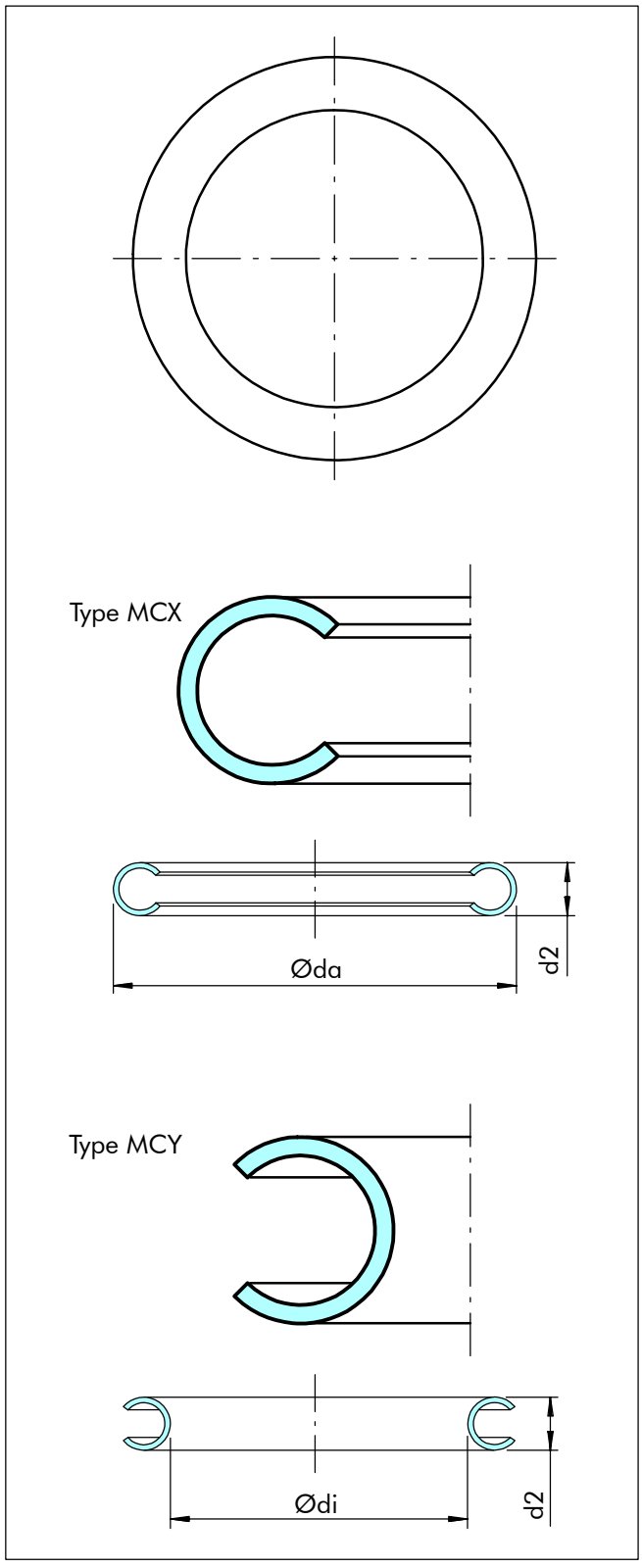


Figure 9 Wills Rings®C - Type MCX/MCY

Size Ranges and Free Heights in Metric

Wills Rings® are available in a comprehensive range of sizes. The free height ranges from 0.89 mm to 9.53 mm. For each size there is a range of seal diameters which can be produced. The free height sizes are industry standard and have evolved from inch sizes. See Tables VII and VIII.

Table VII Diameter Size Range for Wills Rings®O

Free Height d2 mm	Wall Code	Wall Thick-ness mm	Seal ∅ da mm	Total Groove Depth[1] h mm	Groove Width[2] b4 min. mm
0.89	J	0.15	8-50	0.58 +0.08 -0	1.25
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			
7.94	G	1.27	500-2500	6.35 +0.13 -0	10.00
	-	-			
9.53	H	1.52	750-3000	7.92 +0.13 -0	12.00
	R	0.51			

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

Table VIII Diameter Size Range for Wills Rings®C

Free Height d2 mm	Wall Code	Wall Thick-ness mm	Seal ∅ da mm	Total Groove Depth[1] h mm	Groove Width[2] b4 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	50-400	2.54 +0.13 -0	4.00
	M	0.38			
3.97	D	0.61	60-500	3.05 +0.13 -0	5.00
	N	0.41			
4.76	E	0.76	95-500	3.68 +0.13 -0	6.00
	O	0.51			
6.35	-	-	115-500	5.08 +0.13 -0	8.00
	P	0.64			

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

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) - pages 15, 16, (Figures 10, 11, 12 and 13).

2) Groove width given in Table VII and VIII is the minimum. Ideally the groove width b4 = 1.5 x d2.

Compression Loads to Seat Wills Rings®

When Wills Rings® are located in a housing, a specific load must be applied to the flanges to "seat" the seals correctly. "Seating" the seal is the process of compressing it to the correct depth, such that it forms an effective seal. The seating load can be calculated for each seal. The required seating load must be exceeded by the system 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:

$$L_T = L_1 + L_2$$

Where L_T = Total required seating load
L_1 = Load to seat seal
L_2 = Load caused by internal system pressure

The securing system must be sufficiently strong to withstand the pressure and temperature effects during the 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:

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

Note: Wills Rings®C can be hardened to modify the seal resilience. The seating load figures (given in Tables XII & XIII) are for standard treatment seals only (Code Number 2 - short cycle age hardened). If a non-standard seal treatment is used (see Table IX for options), then the correct Material Factor must be used in the seating load calculation - see Table XI.

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 IX Wills Rings®C Material Conditions

Code	Standard	Treatment
1	No	Work harden
2	Yes	Age harden (short cycle)
3	No	Age harden (long cycle)

Hardness/Seal Resilience

Work hardened seals have lower resilience. This can be adequate for PTFE coated Wills Rings®C. This should be used after consulting your Busak+Shamban representative.

Age hardened Wills Rings®C have higher seal resilience. This is required for silver coated Wills Rings®C.

Age harden (short cycle) is adequate for normal sealing.

Age harden (long cycle) can be used to provide higher seating loads. This will provide greater seal resilience to assist sealing in extreme conditions.

The hardness treatment code **must** be included in the Wills Rings®C part number. See the order example 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:

$$L_1 = M \times K \times Dm \times \Pi$$

where L_1 = Load to seat the seal (N)
M = Material factor see Table X or XI
K = Load in N/mm seal circumference see Table XII or XIII
D_m = Median (sealing) diameter of the seal, da - d2 (mm)
Π = Pythagoras constant (3.142)

Table X 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
Mild steel	0.75
Copper	0.50

Table XI Material Factor Wills Rings® C Condition

Material Factor	M
Inconel® X750	1.00
Inconel® 718	1.15

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

Table XII Compressive Load for Standard Wall Wills Rings®

Seal Free Height d2 mm	Size Code	Wills Rings®		Wall Thickness mm	Typical Seating Load per Length Circumference N/mm K	
0.89	-	-	-	-	-	-
1.59	A	O	-	0.36	275	-
		-	C	0.25	-	110
2.38	B	O	-	0.46	248	-
		-	C	0.38	-	150
3.18	C	O	-	0.51	175	-
		-	C	0.51	-	165
3.97	D	O	-	0.64	162	-
		-	C	0.61	-	180
4.76	E	O	-	0.81	230	-
		-	C	0.76	-	190
6.35	F	O	-	1.02	270	-
7.94	G	O	-	1.27	330	-
9.53	H	O	-	1.52	380	-

Table XIII Compressive Load for Thin Wall Wills Rings®

Seal Free Height d2 mm	Size Code	Wills Rings®		Wall Thickness mm	Typical Seating Load per Length Circumference N/mm K	
0.89	J	O	-	0.15	100	-
1.59	K	O	-	0.25	125	-
		-	C	0.15	-	95
2.38	L	O	-	0.25	92	-
		-	C	0.25	-	90
3.18	M	O	-	0.25	58	-
		-	C	0.38	-	92
3.97	N	O	-	0.25	29	-
		-	C	0.41	-	58
4.76	O	O	-	0.25	22	-
		-	C	0.51	-	83
6.35	P	O	-	0.51	52	-
		-	C	0.64	-	85
9.53	R	O	-	0.51	85	-

Groove Designs

Common Groove

There are several types of groove which may be employed to house Wills Rings® depending upon application and the system requirements (Figure 10).

10.1 Closed groove

The seal is enclosed on its inside and outside diameters.

10.2 Open groove

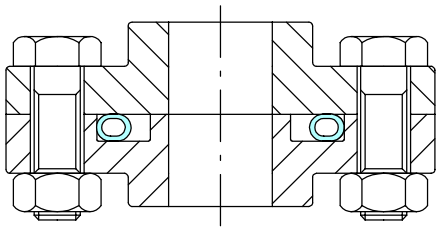
The seal is enclosed by a groove wall opposing the pressure direction (that is, for internal pressure - the groove wall is on the outside of the seal etc.)

10.3 Retainer plate

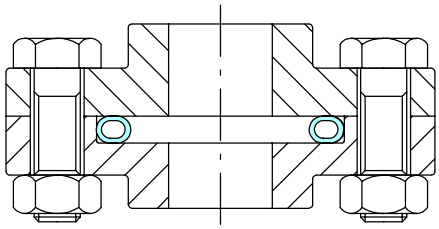
If no groove can be constructed, then a plate of equal depth to the groove can be used to provide support to the seal.

10.4 Seal carrier

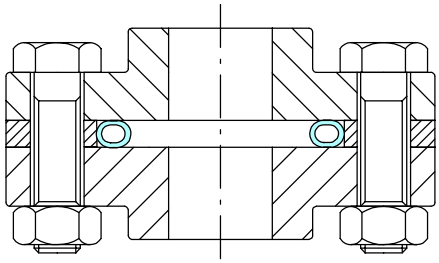
Can be used where deep grooves need to be sealed.



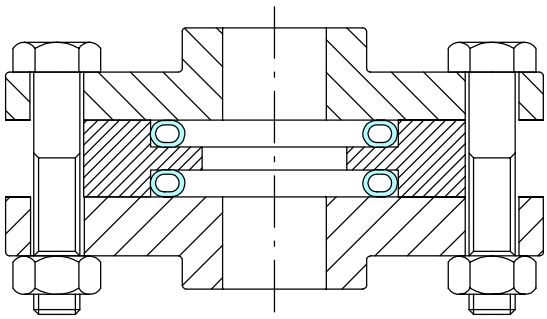
10.1 Closed groove



10.2 Open groove



10.3 Retainer plate



10.4 Seal carrier

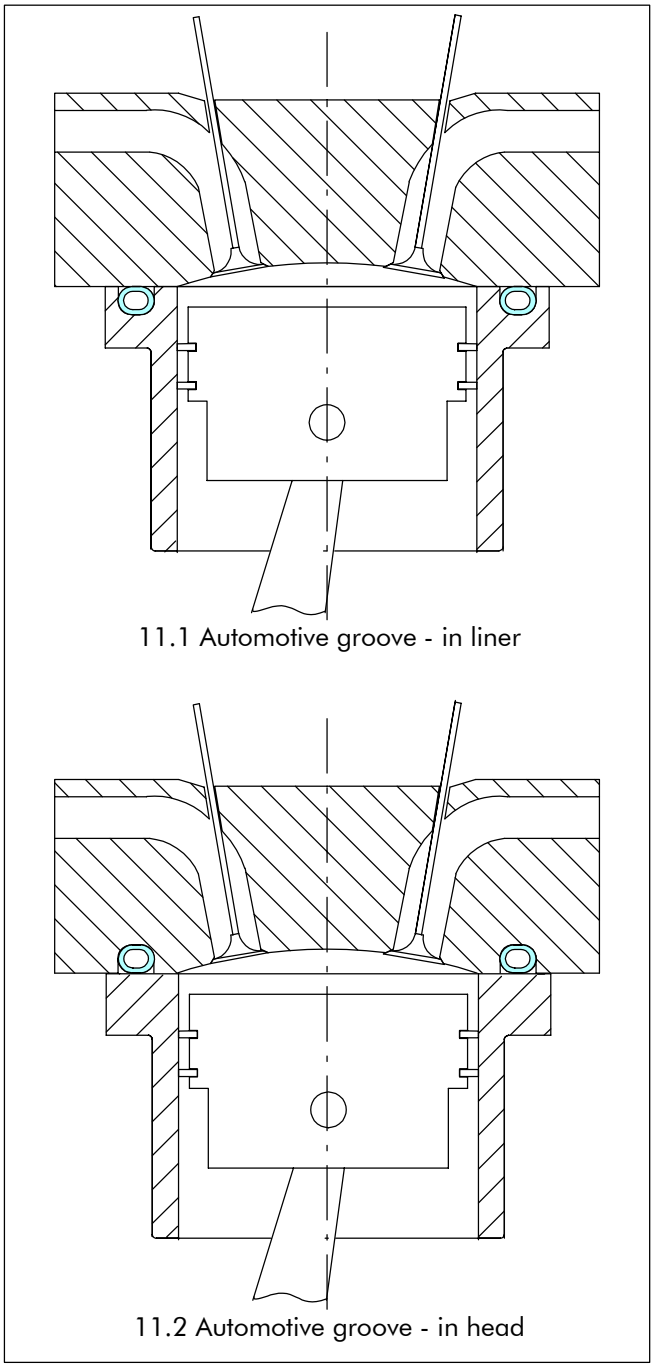
Figure 10 Common installation configuration for Wills Rings®O

All installations above show Wills Rings®O installations.

The same housings can be used for Wills Rings®C installations (see comments about automotive 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 cyclic engine pressures are found, this groove securely holds the Wills Rings® in place. Also the trapped volume of a closed groove is eliminated.



11.1 Automotive groove - in liner

11.2 Automotive groove - in head

Figure 11 Common automotive installation configuration for Wills Rings®O

The housing has a clearance with the seal inside and outside diameters. The groove has a curved base (Figure 12).

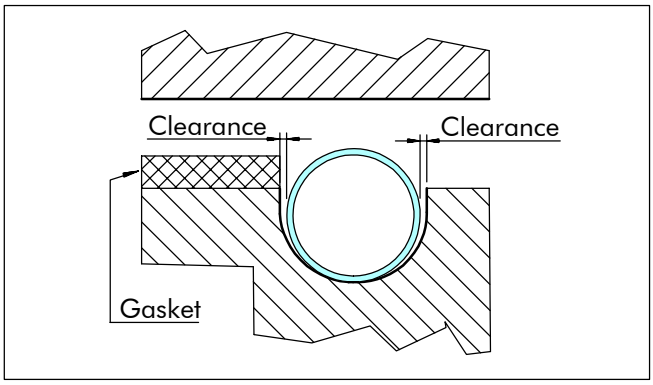


Figure 12 Detail of an automotive groove

Consequently it is held very securely and is protected from the media. This housing groove is preferred for extreme cyclic pressures.

The groove depth given for each free height d2 is the total compressed depth of Wills Rings® when installed. If an additional form of sealing is to be used (e.g.a gasket), then the machined depth of the housing groove must be less.

$$\mathbf{h = M_d + G_d}$$

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

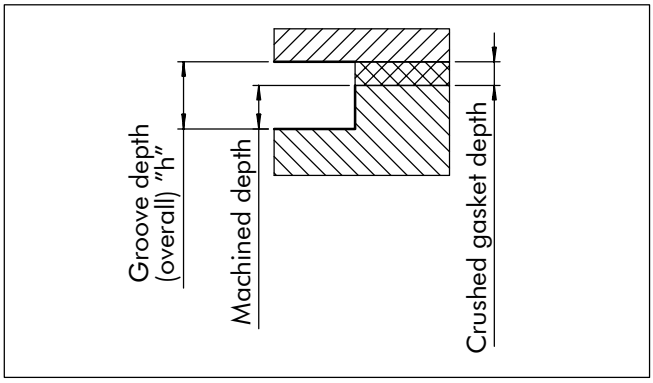


Figure 13 Wills Rings® groove depth with a gasket

Installation Recommendations for Internal Pressure Sealing

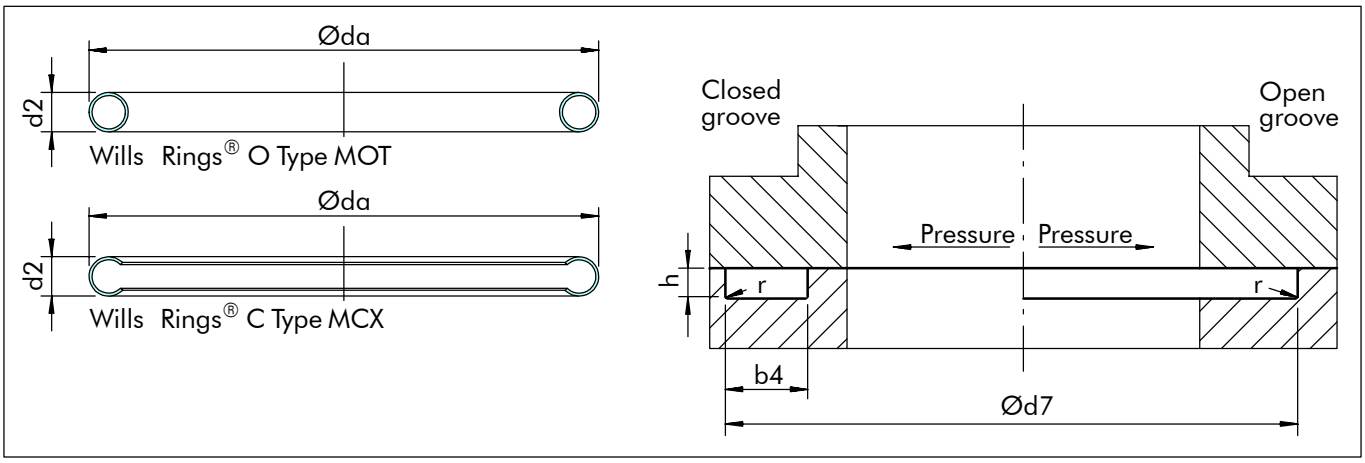


Figure 14 Installation drawing for internal pressure

Table XIV Installation Dimensions for Internal Pressure

Free Height d2 mm	Wills Rings® O Free Height Mat. Codes Stand.	Thin	Wills Rings® C Free Height Mat. Codes Stand.	Thin	Groove Depth h	Groove Width 1) b4 min.	Wills Rings® O 2) Øda	Groove Diameter d7, unplated only 3) = da + clearance + Tolerance		Radius r_{max} mm	Wills Rings® Springback O only	C only
0.89	J		-		0.58 +0.08 -0	1.25	8-50	da +0.10	+0.05	0.25	0.01	-
1.59	K	A	K	A	1.32 +0.08 -0	2.25	12-150	da +0.10	+0.05	0.40	0.02	0.10
2.38	L	B	L	B	1.83 +0.08 -0	3.00	25-500	da +0.18	+0.12	0.50	0.03	0.10
3.18	M	C	M	C	2.54 +0.13 -0	4.00	60-1000	da +0.18	+0.12	0.75	0.03	0.20
3.97	N	D	N	D	3.05 +0.13 -0	5.00	100-1250	da +0.18	+0.12	1.25	0.05	0.25
4.76	O	E	O	E	3.68 +0.13 -0	6.00	115-1500	da +0.25	+0.12	1.50	0.06	0.25
6.35	P	F	P	-	5.08 +0.13 -0	8.00	125-2000	da +0.25	+0.12	1.50	0.07	0.25
7.94	G		-		6.35 +0.13 -0	10.00	500-2500	da +0.38	+0.12	1.50	0.08	-
9.53	R	H	-	-	7.92 +0.13 -0	12.00	750-3000	da +0.38	+0.12	1.50	0.09	-

Notes: 1) Minimum value. Recommended is groove width 1.5 x d2.
2) For Wills Rings®C diameter size ranges see page 12 (Table VIII).
3) Calculate exact groove/seal Ø by the expression:
d7 = da + (2 x maximum coating thickness) + clearance (+ tol.)
= da + CTCV page 18 (Table XV, for clearance tolerance correction value)

for example: for a 3.18 mm Wills Rings®C with 3 layers of plating
d7 = da + (2 x 3 layer coating = 2 x 0.085 mm = 0.170 mm) + clearance (+ tol.)
= da + 0.170 + clearance (+ tol.)
= da + 0.170 + 0.18 (+0.12)
= da + 0.47 mm

Clearance Tolerance Correction Values in Metric

How to size the seal for a given groove diameter (or vice versa)

Table XV Clearance - Tolerance Correction Value in mm

	No Plating		1 Layer		2 Layers		3 Layers	
Max. Plating	0.00		+ 0.035		+ 0.060		+ 0.085	
2 x max. Plating	0.00		+ 0.070		+ 0.120		+ 0.170	
Free Height		**Total**		**Total**		**Total**		**Total**
0.89 1.59	0.10+0.05 0.10+0.05	**0.15**	0.17+0.05 0.17+0.05	**0.22**	0.22+0.05 0.22+0.05	**0.27**	0.27+0.05 0.27+0.05	**0.32**
2.38 3.18 3.97	0.18+0.12 0.18+0.12 0.18+0.12	**0.30**	0.25+0.12 0.25+0.12 0.25+0.12	**0.37**	0.30+0.12 0.30+0.12 0.30+0.12	**0.42**	0.35+0.12 0.35+0.12 0.35+0.12	**0.47**
4.76 6.35	0.25+0.12 0.25+0.12	**0.37**	0.32+0.12 0.32+0.12	**0.44**	0.37+0.12 0.37+0.12	**0.49**	0.42+0.12 0.42+0.12	**0.54**
7.94 9.53	0.38+0.12 0.38+0.12	**0.50**	0.45+0.12 0.45+0.12	**0.57**	0.50+0.12 0.50+0.12	**0.62**	0.55+0.12 0.55+0.12	**0.67**

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 $Ød7 = Øda + CTCV$

External pressure $Ød8 = Ødi - CTCV$

Note:
Use Øda for Wills Rings®O for external pressure
Use Ødi for Wills Rings®C for external pressure

For example

MOT O G1500-1HS

This is a 4.76 mm gas filled Wills Rings®O thin wall seal for a 150.0 mm groove diameter d7. It has silver plate at 3 layers, 0.075/0.085 mm thickness.

The seal diameter is found from $Ød7 = Øda + CTCV$

Hence $Øda = Ød7 - CTCV$
$= 150.0 - 0.54$
$Øda = 149.46$ mm

■ Wills Rings®O for Internal Pressure

These are typical of seal part numbers which can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the order example, pages 23 to 25 and the seal data. See also page 6 (Tables II and IV).

Table XVI Preferred Sizes Wills Rings®O, metric

Groove Ød7 H9	Seal Non-plated	Seal 1 Layer	Seal 3 Layers	Minimum Groove Width b4	Groove Depth h
10.0	MOT J G0100-1H	MOT J G0100-1HR	MOT J G0100-1HS	1.25	0.58/0.66
12.0	MOT J G0120-1H	MOT J G0120-1HR	MOT J G0120-1HS	1.25	0.58/0.66
15.0	MOT A G0150-1H	MOT A G0150-1HR	MOT A G0150-1HS	2.25	1.32/1.40
20.0	MOT A G0200-1H	MOT A G0200-1HR	MOT A G0200-1HS	2.25	1.32/1.40
25.0	MOT A G0250-1H	MOT A G0250-1HR	MOT A G0250-1HS	2.25	1.32/1.40
30.0	MOT B G0300-1H	MOT B G0300-1HR	MOT B G0300-1HS	3.00	1.83/1.91
35.0	MOT B G0350-1H	MOT B G0350-1HR	MOT B G0350-1HS	3.00	1.83/1.91
40.0	MOT B G0400-1H	MOT B G0400-1HR	MOT B G0400-1HS	3.00	1.83/1.91
45.0	MOT B G0450-1H	MOT B G0450-1HR	MOT B G0450-1HS	3.00	1.83/1.91
50.0	MOT B G0500-1H	MOT B G0500-1HR	MOT B G0500-1HS	3.00	1.83/1.91
55.0	MOT B G0550-1H	MOT B G0550-1HR	MOT B G0550-1HS	3.00	1.83/1.91
60.0	MOT B G0600-1H	MOT B G0600-1HR	MOT B G0600-1HS	3.00	1.83/1.91
65.0	MOT C G0650-1H	MOT C G0650-1HR	MOT C G0650-1HS	4.00	2.54/2.67
70.0	MOT C G0700-1H	MOT C G0700-1HR	MOT C G0700-1HS	4.00	2.54/2.67
75.0	MOT C G0750-1H	MOT C G0750-1HR	MOT C G0750-1HS	4.00	2.54/2.67
80.0	MOT C G0800-1H	MOT C G0800-1HR	MOT C G0800-1HS	4.00	2.54/2.67
85.0	MOT C G0850-1H	MOT C G0850-1HR	MOT C G0850-1HS	4.00	2.54/2.67
90.0	MOT C G0900-1H	MOT C G0900-1HR	MOT C G0900-1HS	4.00	2.54/2.67
95.0	MOT C G0950-1H	MOT C G0950-1HR	MOT C G0950-1HS	4.00	2.54/2.67
100.0	MOT C G1000-1H	MOT C G1000-1HR	MOT C G1000-1HS	4.00	2.54/2.67
110.0	MOT D G1100-1H	MOT D G1100-1HR	MOT D G1100-1HS	5.00	3.05/3.18
120.0	MOT D G1200-1H	MOT D G1200-1HR	MOT D G1200-1HS	5.00	3.05/3.18
130.0	MOT D G1300-1H	MOT D G1300-1HR	MOT D G1300-1HS	5.00	3.05/3.18
140.0	MOT D G1400-1H	MOT D G1400-1HR	MOT D G1400-1HS	5.00	3.05/3.18
150.0	MOT D G1500-1H	MOT D G1500-1HR	MOT D G1500-1HS	5.00	3.05/3.18
160.0	MOT D G1600-1H	MOT D G1600-1HR	MOT D G1600-1HS	5.00	3.05/3.18
170.0	MOT E G1700-1H	MOT E G1700-1HR	MOT E G1700-1HS	6.00	3.68/3.81
180.0	MOT E G1800-1H	MOT E G1800-1HR	MOT E G1800-1HS	6.00	3.68/3.81
190.0	MOT E G1900-1H	MOT E G1900-1HR	MOT E G1900-1HS	6.00	3.68/3.81
200.0	MOT E G2000-1H	MOT E G2000-1HR	MOT E G2000-1HS	6.00	3.68/3.81
250.0	MOT E G2500-1H	MOT E G2500-1HR	MOT E G2500-1HS	6.00	3.68/3.81
300.0	MOT F G3000-1H	MOT F G3000-1HR	MOT F G3000-1HS	8.00	5.08/5.21
350.0	MOT F G3500-1H	MOT F G3500-1HR	MOT F G3500-1HS	8.00	5.08/5.21
400.0	MOT F G4000-1H	MOT F G4000-1HR	MOT F G4000-1HS	8.00	5.08/5.21
450.0	MOT F G4500-1H	MOT F G4500-1HR	MOT F G4500-1HS	8.00	5.08/5.21
500.0	MOT F G5000-1H	MOT F G5000-1HR	MOT F G5000-1HS	8.00	5.08/5.21

Use this selection when designing a new housing/sealing system. Also applies to Wills Rings®O for Type MOV/MOW, MOS & MOU.

Note: These seal part numbers use the groove ∅ (indicated by "G" in the ∅ code). This is not equal to the seal ∅. The seal ∅ has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value (Table XV, page 18). The diameter shown is multiplied by a factor of 10 for groove dimensioned seals.

■ Wills Rings®C for Internal Pressure

These are typical of seal part numbers which can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the order example, pages 26 to 27 and the seal data. See also page 6 (Tables III and IV).

Table XVII Preferred Sizes Wills Rings®C, metric

Groove Ød7 H9	Seal 1 Layer	Seal 2 Layers	Seal 3 Layers	Minimum Groove Width b4	Groove Depth h
20.0	MCX A G0200-1NR2	MCX A G0200-1NU2	MCX A G0200-1NS2	2.25	1.32/1.40
25.0	MCX A G0250-1NR2	MCX A G0250-1NU2	MCX A G0250-1NS2	2.25	1.32/1.40
30.0	MCX A G0300-1NR2	MCX A G0300-1NU2	MCX A G0300-1NS2	2.25	1.32/1.40
35.0	MCX A G0350-1NR2	MCX A G0350-1NU2	MCX A G0350-1NS2	2.25	1.32/1.40
40.0	MCX A G0400-1NR2	MCX A G0400-1NU2	MCX A G0400-1NS2	2.25	1.32/1.40
50.0	MCX A G0500-1NR2	MCX A G0500-1NU2	MCX A G0500-1NS2	2.25	1.32/1.40
30.0	MCX B G0300-1NR2	MCX B G0300-1NU2	MCX B G0300-1NS2	3.00	1.83/1.91
40.0	MCX B G0400-1NR2	MCX B G0400-1NU2	MCX B G0400-1NS2	3.00	1.83/1.91
50.0	MCX B G0500-1NR2	MCX B G0500-1NU2	MCX B G0500-1NS2	3.00	1.83/1.91
60.0	MCX B G0600-1NR2	MCX B G0600-1NU2	MCX B G0600-1NS2	3.00	1.83/1.91
70.0	MCX B G0700-1NR2	MCX B G0700-1NU2	MCX B G0700-1NS2	3.00	1.83/1.91
80.0	MCX B G0800-1NR2	MCX B G0800-1NU2	MCX B G0800-1NS2	3.00	1.83/1.91
90.0	MCX B G0900-1NR2	MCX B G0900-1NU2	MCX B G0900-1NS2	3.00	1.83/1.91
70.0	MCX C G0700-1NR2	MCX C G0700-1NU2	MCX C G0700-1NS2	4.00	2.54/2.67
80.0	MCX C G0800-1NR2	MCX C G0800-1NU2	MCX C G0800-1NS2	4.00	2.54/2.67
90.0	MCX C G0900-1NR2	MCX C G0900-1NU2	MCX C G0900-1NS2	4.00	2.54/2.67
100.0	MCX C G1000-1NR2	MCX C G1000-1NU2	MCX C G1000-1NS2	4.00	2.54/2.67
110.0	MCX C G1100-1NR2	MCX C G1100-1NU2	MCX C G1100-1NS2	4.00	2.54/2.67
150.0	MCX C G1500-1NR2	MCX C G1500-1NU2	MCX C G1500-1NS2	4.00	2.54/2.67
110.0	MCX D G1100-1NR2	MCX D G1100-1NU2	MCX D G1100-1NS2	5.00	3.05/3.18
120.0	MCX D G1200-1NR2	MCX D G1200-1NU2	MCX D G1200-1NS2	5.00	3.05/3.18
130.0	MCX D G1300-1NR2	MCX D G1300-1NU2	MCX D G1300-1NS2	5.00	3.05/3.18
140.0	MCX D G1400-1NR2	MCX D G1400-1NU2	MCX D G1400-1NS2	5.00	3.05/3.18
150.0	MCX D G1500-1NR2	MCX D G1500-1NU2	MCX D G1500-1NS2	5.00	3.05/3.18
160.0	MCX D G1600-1NR2	MCX D G1600-1NU2	MCX D G1600-1NS2	5.00	3.05/3.18
160.0	MCX E G1600-1NR2	MCX E G1600-1NU2	MCX E G1600-1NS2	6.00	3.68/3.81
170.0	MCX E G1700-1NR2	MCX E G1700-1NU2	MCX E G1700-1NS2	6.00	3.68/3.81
180.0	MCX E G1800-1NR2	MCX E G1800-1NU2	MCX E G1800-1NS2	6.00	3.68/3.81
190.0	MCX E G1900-1NR2	MCX E G1900-1NU2	MCX E G1900-1NS2	6.00	3.68/3.81
200.0	MCX E G2000-1NR2	MCX E G2000-1NU2	MCX E G2000-1NS2	6.00	3.68/3.81
160.0	MCX P G1600-1NR2	MCX P G1600-1NU2	MCX P G1600-1NS2	8.00	5.08/5.21
170.0	MCX P G1700-1NR2	MCX P G1700-1NU2	MCX P G1700-1NS2	8.00	5.08/5.21
180.0	MCX P G1800-1NR2	MCX P G1800-1NU2	MCX P G1800-1NS2	8.00	5.08/5.21
190.0	MCX P G1900-1NR2	MCX P G1900-1NU2	MCX P G1900-1NS2	8.00	5.08/5.21
200.0	MCX P G2000-1NR2	MCX P G2000-1NU2	MCX P G2000-1NS2	8.00	5.08/5.21

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

Note: These seal part numbers use the groove ∅ (indicated by "G" in the ∅ code). This is not equal to the seal ∅.
The seal ∅ has a clearance fit depending upon the plating used. See the Clearance - Tolerance Correction Value (Table XV page 18).
The diameter shown is multiplied by a factor of 10 for groove dimensioned seals.

Installation Recommendations for External Pressure Sealing

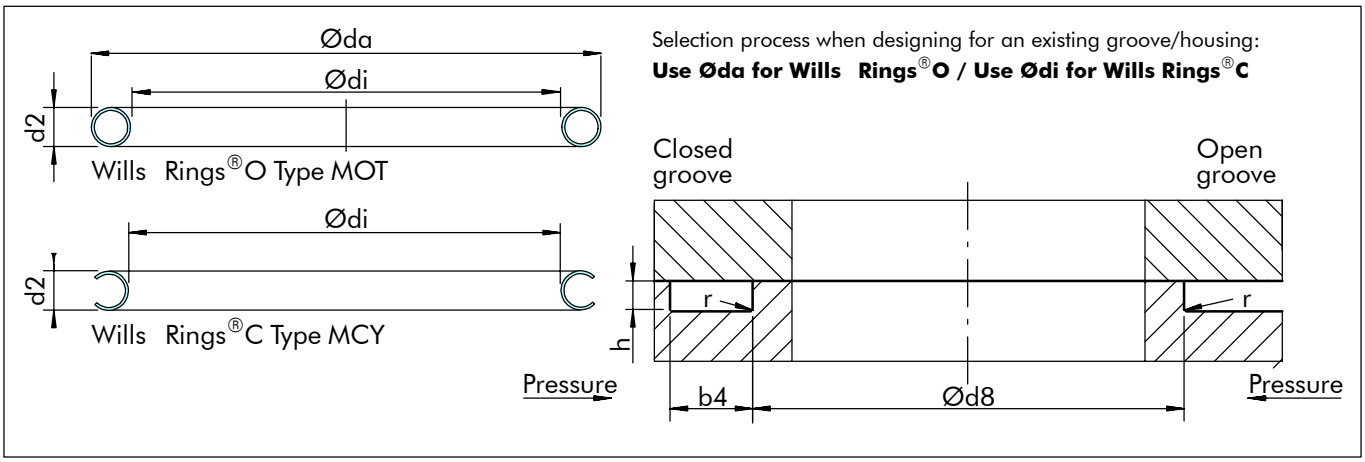


Figure 15 Installation drawing for external pressure

Table XVIII Installation Dimensions for External Pressure

Free Height d2 mm	Wills Rings® O Free Height Mat. Codes Stand	Thin	Wills Rings® C Free Height Mat. Codes Stand	Thin	Groove Depth h	Groove Width 1) b4 min.	Wills Rings® O 2) Øda	Groove Diameter d8, unplated only 3) = di - clearance - tolerance		Radius r_{max} mm	Wills Rings® Springback O only	C only
0.89		J	-		0.58 +0.08 -0	1.25	8-50	di -0.10	-0.05	0.25	0.01	-
1.59		K		K	1.32 +0.08 -0	2.25	12-150	di -0.10	-0.05	0.40	0.02	0.10
	A		A									
2.38		L		L	1.83 +0.08 -0	3.00	25-500	di -0.18	-0.12	0.50	0.03	0.10
	B		B									
3.18		M		M	2.54 +0.13 -0	4.00	60-1000	di -0.18	-0.12	0.75	0.03	0.20
	C		C									
3.97		N		N	3.05 +0.13 -0	5.00	100-1250	di -0.18	-0.12	1.25	0.05	0.25
	D		D									
4.76		O		O	3.68 +0.13 -0	6.00	115-1500	di -0.25	-0.12	1.50	0.06	0.25
	E		E									
6.35		P		P	5.08 +0.13 -0	8.00	125-2000	di -0.25	-0.12	1.50	0.07	0.25
	F		-									
7.94	G		-		6.35 +0.13 -0	10.00	500-2500	di -0.38	-0.12	1.50	0.08	-
9.53		R	-		7.92 +0.13 -0	12.00	750-3000	di -0.38	-0.12	1.50	0.09	-
	H		-									

Notes: 1) Minimum value. Recommended is groove width 1.5 x d2.
2) For Wills Rings® C diameter size ranges see page 12 (Table VIII).
3) Calculate exact groove/seal Ø by the expression:
d8 = di - (2 x maximum coating thickness) - clearance (- tol.)
d8 = di - CTCV (page 18 Table XV, for clearance tolerance correction value)

for example: for a 2.38 mm Wills Rings® O with 1 layer of plating
d8 = di - (2 x 1 layer coating = 2 x 0.035 mm = 0.070 mm) - clearance (- tol.)
= di - 0.070 - clearance (- tol.)
= di - 0.070 - 0.18 (-0.12)
= di - 0.37 mm

Wills Rings®C for External Pressure

These are typical of seal part numbers which can be ordered using the groove diameter. Other sizes, materials or finishes may be ordered by referring to the order example, pages 26 to 27 and the seal data. See also page 6 (Tables III and IV).

Table XIX Preferred Sizes Wills Rings®C, metric

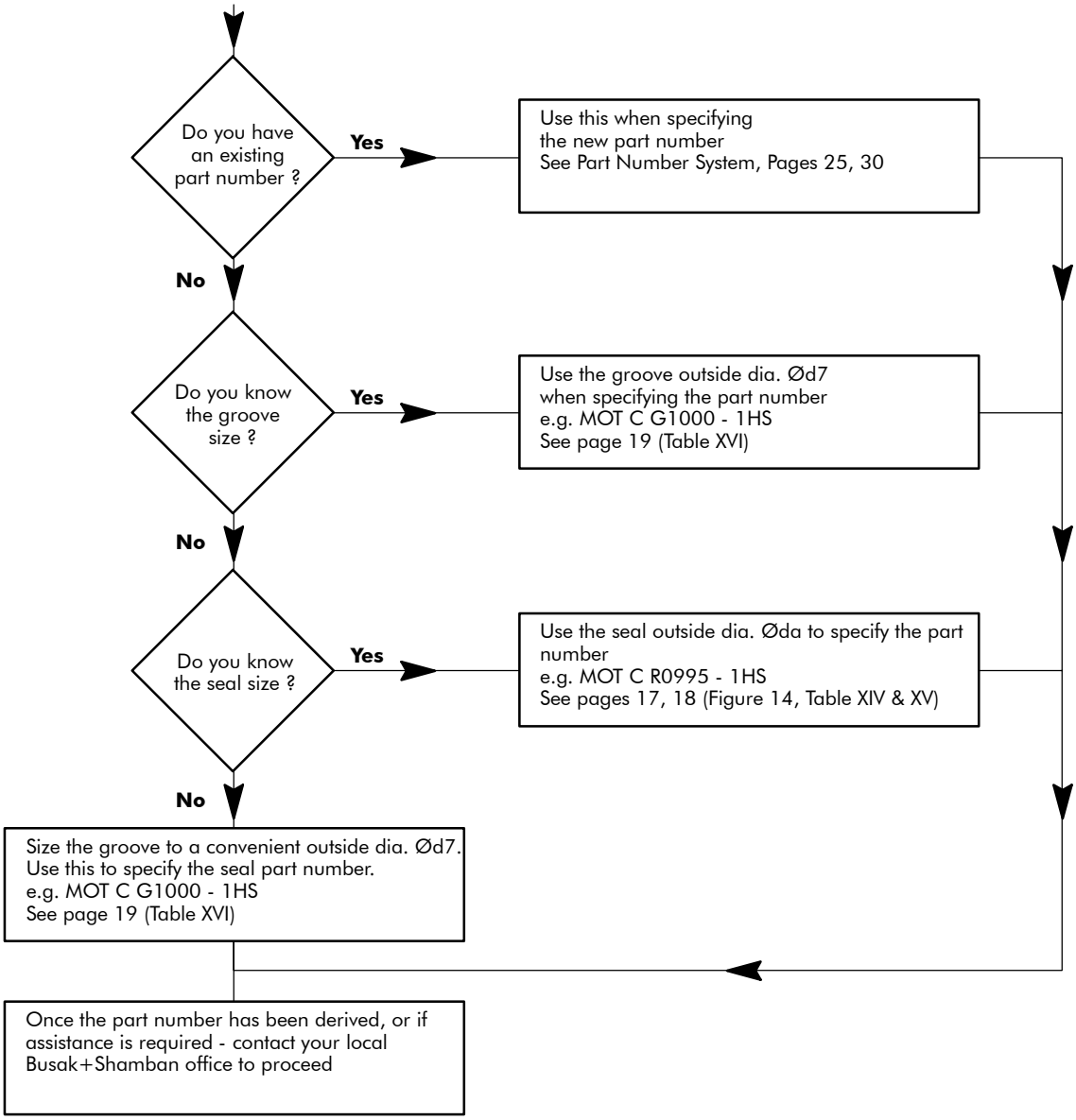
Groove Ød8 h9	Seal 1 Layer	Seal 2 Layers	Seal 3 Layers	Minimum Groove Width b4	Groove Depth h
20.0	MCY A G0200-1NR2	MCY A G0200-1NU2	MCY A G0200-1NS2	2.25	1.32/1.40
25.0	MCY A G0250-1NR2	MCY A G0250-1NU2	MCY A G0250-1NS2	2.25	1.32/1.40
30.0	MCY A G0300-1NR2	MCY A G0300-1NU2	MCY A G0300-1NS2	2.25	1.32/1.40
35.0	MCY A G0350-1NR2	MCY A G0350-1NU2	MCY A G0350-1NS2	2.25	1.32/1.40
40.0	MCY A G0400-1NR2	MCY A G0400-1NU2	MCY A G0400-1NS2	2.25	1.32/1.40
50.0	MCY A G0500-1NR2	MCY A G0500-1NU2	MCY A G0500-1NS2	2.25	1.32/1.40
30.0	MCY B G0300-1NR2	MCY B G0300-1NU2	MCY B G0300-1NS2	3.00	1.83/1.91
40.0	MCY B G0400-1NR2	MCY B G0400-1NU2	MCY B G0400-1NS2	3.00	1.83/1.91
50.0	MCY B G0500-1NR2	MCY B G0500-1NU2	MCY B G0500-1NS2	3.00	1.83/1.91
60.0	MCY B G0600-1NR2	MCY B G0600-1NU2	MCY B G0600-1NS2	3.00	1.83/1.91
70.0	MCY B G0700-1NR2	MCY B G0700-1NU2	MCY B G0700-1NS2	3.00	1.83/1.91
80.0	MCY B G0800-1NR2	MCY B G0800-1NU2	MCY B G0800-1NS2	3.00	1.83/1.91
90.0	MCY B G0900-1NR2	MCY B G0900-1NU2	MCY B G0900-1NS2	3.00	1.83/1.91
70.0	MCY C G0700-1NR2	MCY C G0700-1NU2	MCY C G0700-1NS2	4.00	2.54/2.67
80.0	MCY C G0800-1NR2	MCY C G0800-1NU2	MCY C G0800-1NS2	4.00	2.54/2.67
90.0	MCY C G0900-1NR2	MCY C G0900-1NU2	MCY C G0900-1NS2	4.00	2.54/2.67
100.0	MCY C G1000-1NR2	MCY C G1000-1NU2	MCY C G1000-1NS2	4.00	2.54/2.67
110.0	MCY C G1100-1NR2	MCY C G1100-1NU2	MCY C G1100-1NS2	4.00	2.54/2.67
150.0	MCY C G1500-1NR2	MCY C G1500-1NU2	MCY C G1500-1NS2	4.00	2.54/2.67
110.0	MCY D G1100-1NR2	MCY D G1100-1NU2	MCY D G1100-1NS2	5.00	3.05/3.18
120.0	MCY D G1200-1NR2	MCY D G1200-1NU2	MCY D G1200-1NS2	5.00	3.05/3.18
130.0	MCY D G1300-1NR2	MCY D G1300-1NU2	MCY D G1300-1NS2	5.00	3.05/3.18
140.0	MCY D G1400-1NR2	MCY D G1400-1NU2	MCY D G1400-1NS2	5.00	3.05/3.18
150.0	MCY D G1500-1NR2	MCY D G1500-1NU2	MCY D G1500-1NS2	5.00	3.05/3.18
160.0	MCY D G1600-1NR2	MCY D G1600-1NU2	MCY D G1600-1NS2	5.00	3.05/3.18
160.0	MCY E G1600-1NR2	MCY E G1600-1NU2	MCY E G1600-1NS2	6.00	3.68/3.81
170.0	MCY E G1700-1NR2	MCY E G1700-1NU2	MCY E G1700-1NS2	6.00	3.68/3.81
180.0	MCY E G1800-1NR2	MCY E G1800-1NU2	MCY E G1800-1NS2	6.00	3.68/3.81
190.0	MCY E G1900-1NR2	MCY E G1900-1NU2	MCY E G1900-1NS2	6.00	3.68/3.81
200.0	MCY E G2000-1NR2	MCY E G2000-1NU2	MCY E G2000-1NS2	6.00	3.68/3.81
160.0	MCY P G1600-1NR2	MCY P G1600-1NU2	MCY P G1600-1NS2	8.00	5.08/5.21
170.0	MCY P G1700-1NR2	MCY P G1700-1NU2	MCY P G1700-1NS2	8.00	5.08/5.21
180.0	MCY P G1800-1NR2	MCY P G1800-1NU2	MCY P G1800-1NS2	8.00	5.08/5.21
190.0	MCY P G1900-1NR2	MCY P G1900-1NU2	MCY P G1900-1NS2	8.00	5.08/5.21
200.0	MCY P G2000-1NR2	MCY P G2000-1NU2	MCY P G2000-1NS2	8.00	5.08/5.21

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

Note: These seal part numbers use the groove Ød8 (indicated by "G" in the part number). This is not equal to the seal Ødi. The seal diameter Ødi is found by using the CTCV as given in Table XV, page 18.
The diameter shown in the part number is multiplied by a factor of 10 for groove dimensioned seals.

■ Part Number and Ordering Instructions in Metric

1. Wills Rings® O Internal Pressure (Sealing on the Outside Diameter)

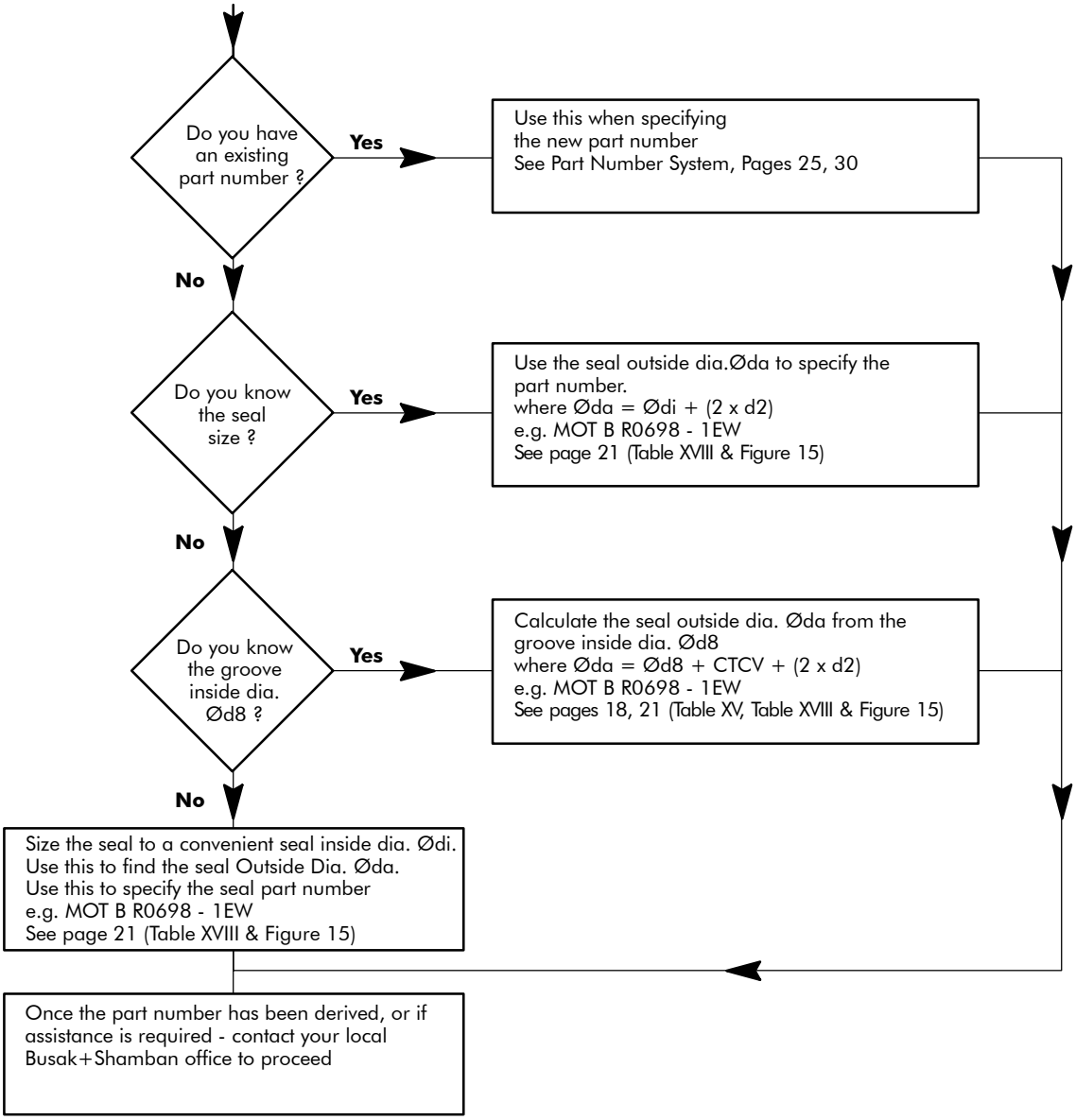


Dimensions are:
Øda = Seal outside diameter
Ødi = Seal inside diameter
Ød7 = Groove outside diameter
Ød8 = Groove inside diameter
d2 = Seal free height
Øda = Ød7 - CTCV
Ødi = Ød8 + CTCV
Øda = Ødi + (2 x d2)

Example:
Groove outside dia. Ød7 = 100.00 mm
Seal outside dia. Øda = 99.53 mm
Seal 3.18 mm standard wall 316L stainless steel + 3 layers of silver plate gas filled Wills Rings®O
Clearance tolerance correction value - see page 18 (Table XV)
(CTCV) = 0.47 mm

The part number for this could be:
MOT C G1000 - 1HS (when based on the groove dia.)
MOT C R0995 - 1HS (when based on the seal dia.)

2. Wills Rings® O External Pressure (Sealing on the Inside Diameter)



Dimensions are:
Øda = Seal outside diameter
Ødi = Seal inside diameter
Ød7 = Groove outside diameter
Ød8 = Groove inside diameter
d2 = Seal free height
Øda = Ød7 - CTCV
Ødi = Ød8 + CTCV
Øda = Ødi + (2 x d2)

Note: For external pressure, seal on groove inside Dia. Ød8, the seal cannot be specified using groove inside Dia. Ød8 for Wills Rings®O. This seal must be specified using the seal outside dia. Øda.

Example:
Groove inside dia. Ød8 = 64.63 mm
Seal inside dia. Ødi = 65.00 mm
Seal outside dia. Øda = 69.76 mm
Seal free height d2 = 2.38 mm
Standard wall 321 SS + PTFE coating
Gas filled Wills Rings®O
Clearance tolerance correction value
(CTCV) = 0.37 mm

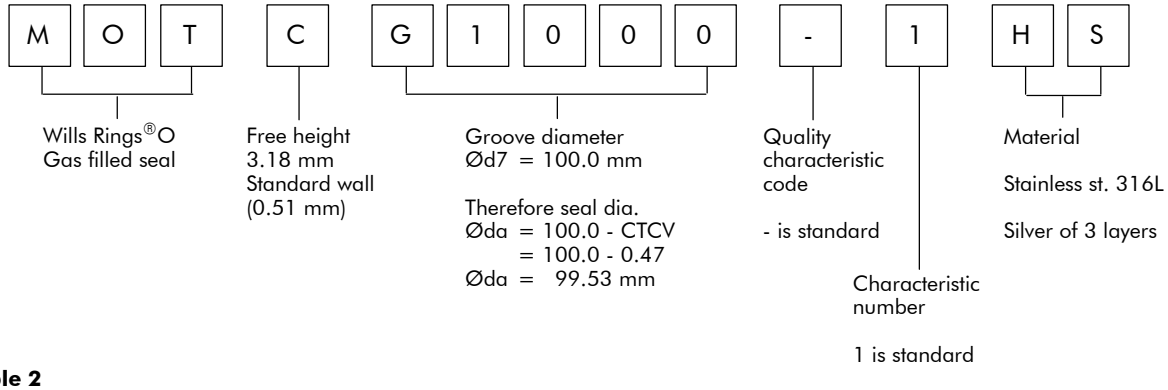
The part number for this is:
MOT B R0698 - 1EW (based on the seal outside dia.)

■ Part Number Systems for Wills Rings® in Metric

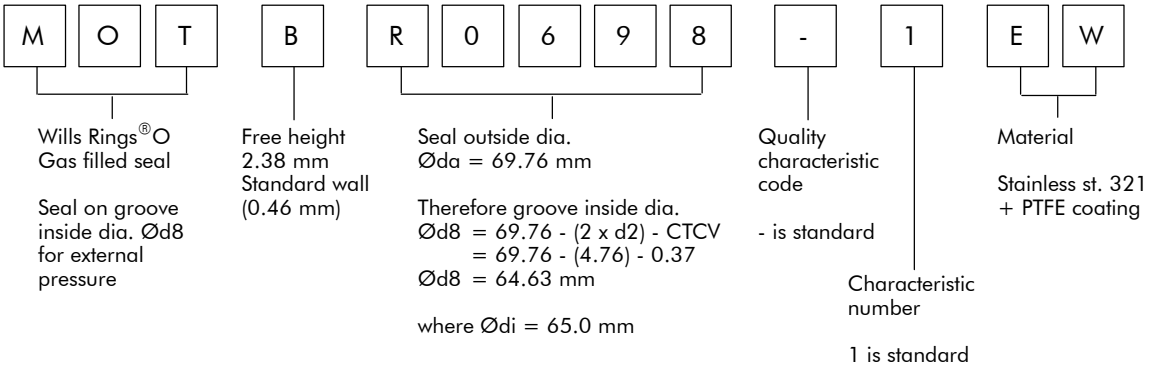
Table XX Part Number System for Wills Rings®O in Metric

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	S Solid T Gas-filled U Non-pressurized V Pressure vented ID W Pressure vented OD	Standard wall A 1.59 0.36 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 G 7.94 1.27 H 9.53 1.52 Thin wall J 0.89 0.15 K 1.59 0.25 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 R 9.53 0.51	Diameter x 10 (up to) 999.9) G - - - - this is the groove outside dia. Ød7 x 10 Use the groove method only for internal pressure/ external sealing Alternatively R - - - - this is the ring outside dia. Øda x 10	"-" Standard Quality "K" X-Ray required "A" Aerospace use	1 = Standard	B Mild steel H Stainless st. AISI 316L (1.4435) E Stainless st. AISI 321 (1.4541) M Inconel® 600 O Copper	W PTFE Q Nickel R Silver 1 layer U Silver 2 layers S Silver 3 layers

Example 1

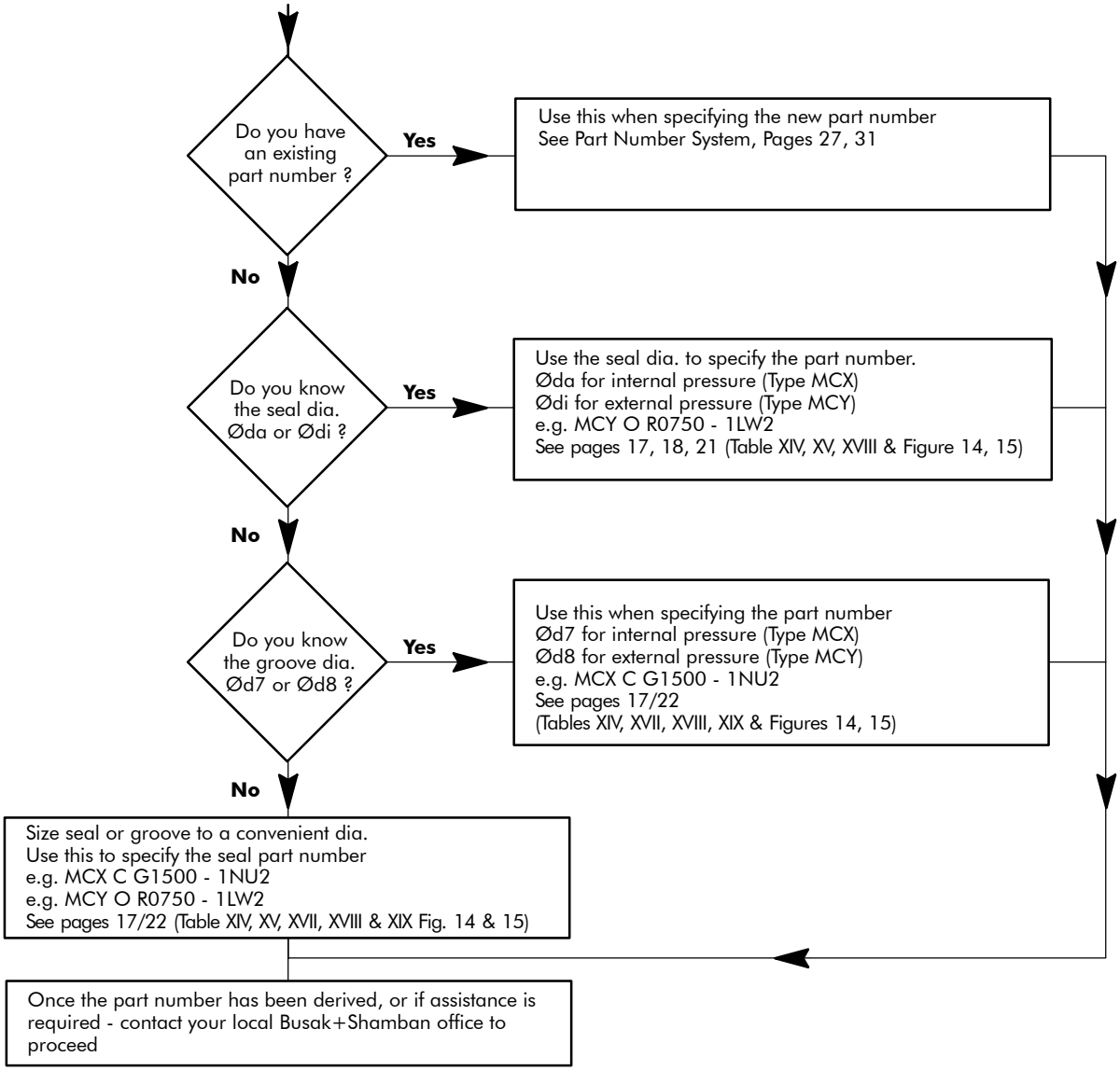


Example 2



See page 30 for Part Number System in Inches.

3. Wills Rings®C Internal Pressure (Sealing on the Outside Diameter) & External Pressure (Sealing on the Inside Diameter)



Dimensions are:
Øda = Seal outside diameter
Ødi = Seal inside diameter
Ød7 = Groove outside diameter
Ød8 = Groove inside diameter
d2 = Seal free height
Øda = Ød7 - CTCV
Ødi = Ød8 + CTCV
but
Øda # Ødi + (2 x d2)

Example:
Seal inside dia. Ødi = 75.00 mm
Groove inside dia. Ød8 = 74.56 mm
Seal free height d2 = 4.76 mm
Thin wall Inconel® 718 + PTFE coating
External pressure Wills Rings®C type MCY
Clearance tolerance correction value (CTCV) = 0.44 mm

The part number for this could be:
MCY O R0750-ILW 2 or
MCY O G0746-ILW 2

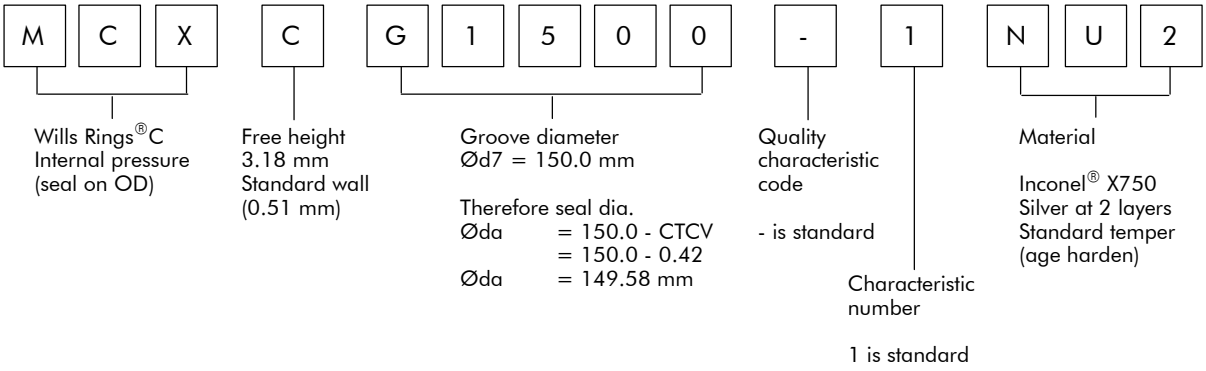
Note: Type MCX
For internal pressure, sealing on the outside dia. - use the seal outside dia. Øda, or the groove outside dia. Ød7 to size the Wills Rings®C seal.

Type MCY
For external pressure, sealing on the inside dia. - use the seal inside dia. Ødi, or the groove inside dia. Ød8 to size the Wills Rings®C seal.

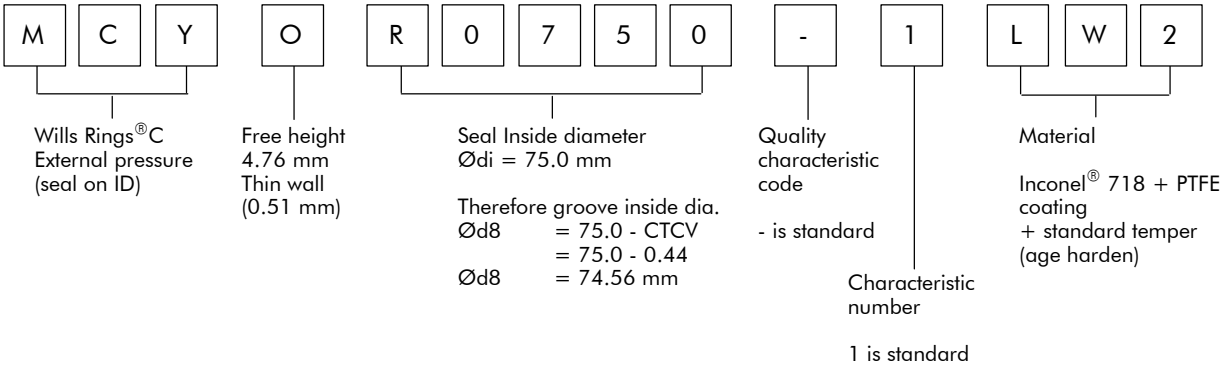
Table XXI Part Number System for Wills Rings®C in Metric

Seal Type	Series	Free Height/ Wall Size mm	Seal Diameter	Quality Characteristic Code	Charac-teristic Number	Seal Material	Coating Material	Treatment
M C M: Metal C: C-Ring profile	X Internal pressure Y External pressure	Standard wall A 1.59 0.25 B 2.38 0.38 C 3.18 0.51 D 3.97 0.61 E 4.76 0.76 Thin wall 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	(up to 999.9) G - - - - this is the groove dia. (Ød7 or Ød8) x 10 R - - - - this is the seal dia. (Øda or Ødi) x 10 Use outside dia. for internal pressure/outside sealing Use inside dia. for external pressure/inside sealing	"-" Standard Quality "A" Aerospace use	1=Standard	L Inconel® 718 N Inconel® X750	W PTFE R Silver 1 layer U Silver 2 layers S Silver 3 layers	1 = Work harden 2 = Standard age harden (short cycle) 3 = Age harden (long cycle)

Example 1



Example 2



See page 31 for Part Number System in Inches

Size Ranges and Free Heights in Inches

This catalogue has mostly been based upon metric dimensions. However, in some markets inches are the preferred units of size. Here follows some tables giving inch nominal equivalents of the Wills Rings® metric sizes.

Wills Rings® are available in a comprehensive range of sizes. The free height ranges from 0.035" to 0.375". For each size there is a range of seal diameters which can be produced.

Table XXII Diameter Size Range in Inches for Wills Rings® O

Free Height d2 inch	Wall Code	Wall inch	Seal ∅ da inch	Total Groove Depth[1] h inch	Groove Width[2] b4 min. inch
0.035	J	0.006	0.313-2	0.023 +0.003 -0	0.050
0.063	A	0.014	0.5-6	0.052 +0.003 -0	0.100
	K	0.010			
0.094	B	0.018	1-20	0.072 +0.003 -0	0.135
	L	0.010	2-20		
0.125	C	0.020	2.5-40	0.100 +0.005 -0	0.200
	M	0.010			
0.156	D	0.025	4-60	0.120 +0.005 -0	0.225
	N	0.010			
0.187	E	0.032	4.5-60	0.145 +0.005 -0	0.250
	O	0.010	6-60		
0.250	F	0.040	5-80	0.200 +0.005 -0	0.350
	P	0.020			
0.313	G	0.050	20-100	0.250 +0.005 -0	0.400
	-	-			
0.375	H	0.060	30-120	0.312 +0.005 -0	0.500
	R	0.020			

See page 12 for Size Ranges and Free Heights in Metric.

Table XXIII Diameter Size Range in Inches for Wills Rings® C

Free Height d2 inch	Wall Code	Wall inch	Seal ∅ da inch	Total Groove Depth[1] h inch	Groove Width[2] b4 min. inch
-	-	-	-	-	-
0.063	A	0.010	0.8-6	0.052 +0.003 -0	0.100
	K	0.006			
0.094	B	0.015	1-12	0.072 +0.003 -0	0.135
	L	0.010			
0.125	C	0.020	2-16	0.100 +0.005 -0	0.200
	M	0.015			
0.156	D	0.024	2.4-20	0.120 +0.005 -0	0.225
	N	0.016			
0.187	E	0.030	3.75-20	0.145 +0.005 -0	0.250
	O	0.020			
0.250	-	-	4.5-20	0.200 +0.005 -0	0.350
	P	0.025			

See page 12 for Size Ranges and Free Heights in Metric.

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) - pages 15, 16, (Figures 10, 11, 12 and 13).

2) Groove width given in Table XXII and XXIII is the minimum. Ideally the groove width b4 = 1.5 x d2.

Clearance Tolerance Correction Values in Inches

How to size the seal for a given groove diameter (or vice versa)

Table XXIV Clearance - Tolerance Correction Value in Inches

	No Plating		1 Layer		2 Layers		3 Layers	
Max. Plating	0.00		+ 0.0015		+ 0.0025		+ 0.0035	
2 x max. Plating	0.00		+ 0.003		+ 0.005		+ 0.007	
Free Height		**Total**		**Total**		**Total**		**Total**
0.035 0.063	0.004+0.002 0.004+0.002	**0.006**	0.007+0.002 0.007+0.002	**0.009**	0.009+0.002 0.009+0.002	**0.011**	0.011+0.002 0.011+0.002	**0.013**
0.094 0.125 0.156	0.007+0.005 0.007+0.005 0.007+0.005	**0.012**	0.010+0.005 0.010+0.005 0.010+0.005	**0.015**	0.012+0.005 0.012+0.005 0.012+0.005	**0.017**	0.014+0.005 0.014+0.005 0.014+0.005	**0.019**
0.187 0.250	0.010+0.005 0.010+0.005	**0.015**	0.013+0.005 0.013+0.005	**0.018**	0.015+0.005 0.015+0.005	**0.020**	0.017+0.005 0.017+0.005	**0.022**
0.313 0.375	0.015+0.005 0.015+0.005	**0.020**	0.018+0.005 0.018+0.005	**0.023**	0.020+0.005 0.020+0.005	**0.025**	0.022+0.005 0.022+0.005	**0.027**

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

Internal pressure Ød7 = Øda + CTCV

External pressure Ød8 = Ødi - CTCV

Note:
Use Øda for Wills Rings®O for external pressure
Use Ødi for Wills Rings®C for external pressure

For example

MOT O L1200-1HS

This is a 0.187" gas filled Wills Rings®O thin wall seal for a 12.00" seal diameter da. It has silver plate at 3 layers, 0.003/0.0035" thickness.

The groove diameter is found from Ød7 = Øda + CTCV

Hence Ød7 = Øda + CTCV
= 12.00 + 0.022
Ød7 = 12.022"

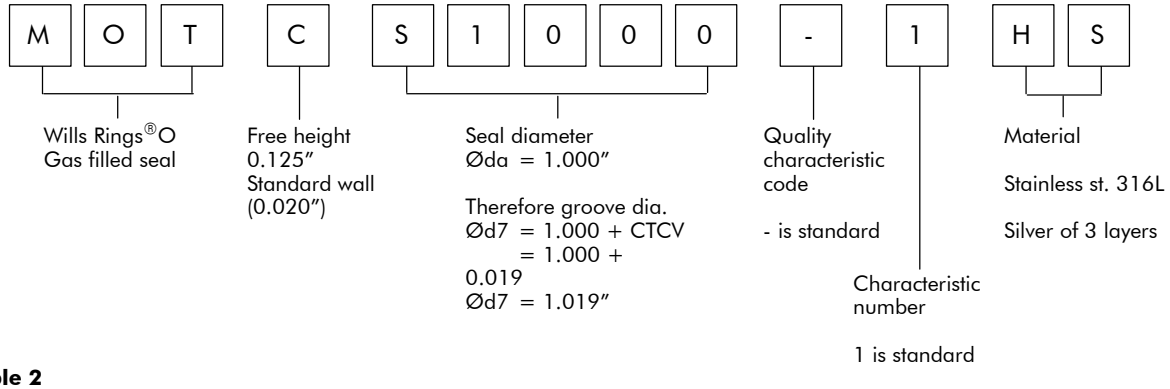
See page 18 for Clearance Tolerance Correction Values in Metric.

Part Number Systems for Wills Rings® in Inches

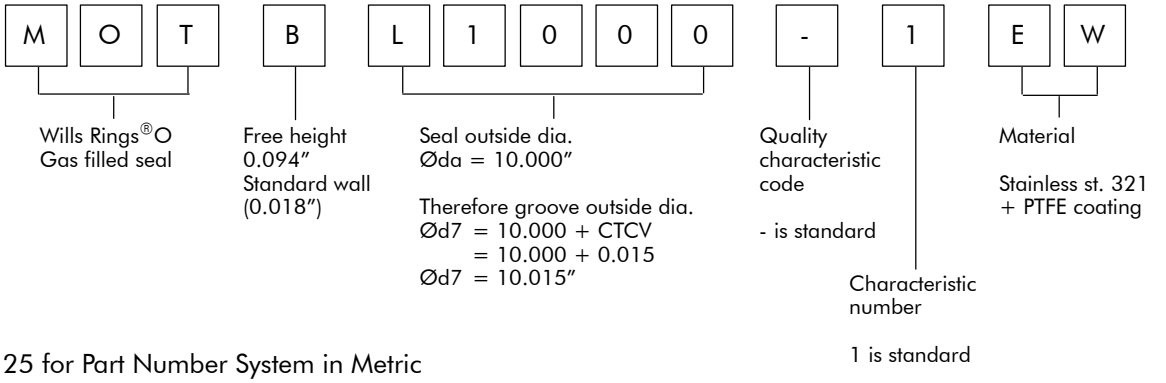
Table XXV Part Number System for Wills Rings®O in Inches

Seal Type	Series	Free Height/ Wall Size inch	Seal Diameter	Quality Characteristic Code	Characteristic Number	Seal Material	Coating Material
M O M: Metal O: O-Ring profile	S Solid T Gas-filled U Non-pressurized V Pressure vented ID W Pressure vented OD	Standard wall A .063 .014 B .094 .018 C .125 .020 D .156 .025 E .187 .032 F .250 .040 G .313 .050 H .375 .060 Thin wall J .035 .006 K .063 .010 L .094 .010 M .125 .010 N .156 .010 O .187 .010 P .250 .020 R .375 .020	For small dia. up to 9.999″ use S - - - - this is the seal outside dia. Øda to 3 decimal places For larger dia. above 10.000″ use L - - - - this is the seal outside dia. Øda to 2 decimal places	″-″ Standard Quality ″K″ X-Ray required ″A″ Aerospace use	1 = Standard	B Mild steel H Stainless st. AISI 316L (1.4435) E Stainless st. AISI 321 (1.4541) M Inconel® 600 O Copper	W PTFE Q Nickel R Silver 1 layer U Silver 2 layers S Silver 3 layers

Example 1



Example 2

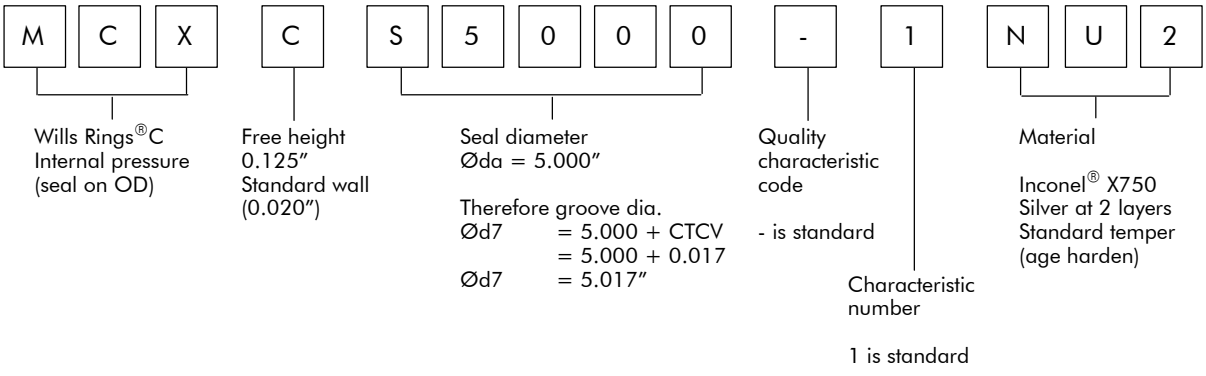


See page 25 for Part Number System in Metric

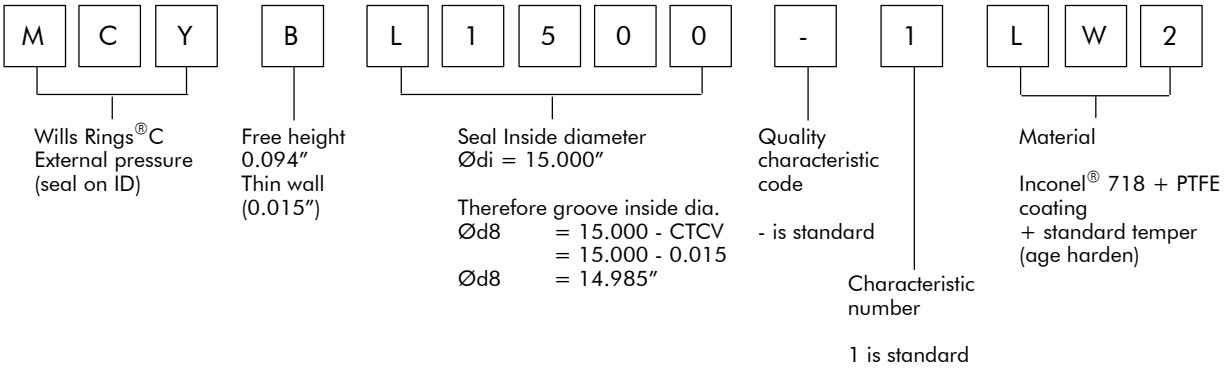
Table XXVI Part Number System for Wills Rings®C in Inches

Seal Type	Series	Free Height/ Wall Size inch	Seal Diameter	Quality Characteristic Code	Charac-teristic Number	Seal Material	Coating Material	Treatment
M C M: Metal C: C-Ring profile	X Internal pressure Y External pressure	Standard wall A .063 .010 B .094 .015 C .125 .020 D .156 .024 E .187 .030 Thin wall K .063 .006 L .094 .010 M .125 .015 N .156 .016 O .187 .020 P .250 .025	For small dia. up to 9.999″ use S - - - - this is the seal outside dia. Øda to 3 decimal places For larger dia. above 10.000″ use L - - - - this is the seal outside dia. Øda to 2 decimal places Use outside dia. for internal pressure/outside sealing Use inside dia. for external pressure/inside sealing	″-″ Standard Quality ″A″ Aerospace use	1 = Standard	L Inconel® 718 N Inconel® X750	W PTFE R Silver 1 layer U Silver 2 layers S Silver 3 layers	1 = Work harden 2 = Standard age harden (short cycle) 3 = Age harden (long cycle)

Example 1



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 applied in production. Seals and bearings manufactured by Busak+Shamban are continuously monitored according to strict quality standards from material acquisition through to delivery.

Certification of our production plants in accordance with international standards EN ISO 9000 meets the specific requirements for quality control and management of purchasing, production and marketing functions.

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

All testing of materials and products is performed in accordance with accepted test standards and specifications, e.g. random sample testing in accordance with DIN ISO 2859 part 1/ANSI/ASQC Z 1.4-1993/ MIL-STD- 105 E. Inspection specifications correspond to standards applicable to individual product groups (e.g. for O-Rings: ISO 3601/DIN 3771).

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 catalogue. Customer-specific requirements are indicated by a different symbol in this position. Customers who require special quality criteria should contact their local Busak+Shamban sales office for assistance. We have experience in meeting all 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 during storage.

Under the influence of various external factors e.g. heat, moisture, light, oxygen, ozone and as a result of contact with liquid media, the properties of certain materials may change. For example, deformation, ageing and weathering can cause deterioration of the original mechanical and physical properties, depending on the material and shape of the parts.

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% rel. moisture ±10).

Weathering

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

Conversion Tables

SI - Basic Units

Measures	Units	Symbol
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mol	mol

Surface Finish R_a

µm	µin
0.1	4
0.2	8
0.4	16
0.8	32
1.6	64

Length

	inch	foot	yard	mm	metre
1 inch =		0.0833	0.0278	25.4	0.0254
1 foot =	12		0.333	304.8	0.3048
1 yard =	36	3		914.4	0.9144
1 mm =	0.03937	0.0033	0.00109		0.001
1 metre =	39.37	3.2808	1.0936	1.000	

Temperature

	Kelvin	°C	°F
1 Kelvin =		K - 273.15	K 9/5 - 459.67
1 °C =	°C + 273.15		°C 9/5 + 32
1 °F =	5/9 (°F-32) + 273.15	(°F-32) x 5/9	

Torque

	inch-ounce	inch-pound	foot-pound	kg-metre	Newton-metre
1 inch-ounce =		0.0625	0.0052	7.2×10^{-4}	7.06×10^{-3}
1 inch-pound =	16		0.0833	1.152×10^{-2}	0.1130
1 foot-pound =	192	12		0.1383	1.356
1 kg-metre =	1 388.7	86.796	7.233		9.80665
1 Newton-metre =	141.6	8.850	0.7375	0.1020	

Density

	ounce/inch^3	pound/foot^3	g/cm^3
1 ounce/inch^3 =		108	1.73
1 pound/foot^3 =	0.0092		0.016
1 g/cm^3 =	0.578	62.43	

Area

	inch^2	foot^2	yard^2	mm^2	m^2
1 inch^2 =		0.0069	0.00077	645.16	6.45×10^{-4}
1 foot^2 =	144		0.111	92.903	0.0929
1 yard^2 =	1.296	9		836.100	0.8361
1 mm^2 =	0.0016	1.0764×10^{-5}	1.196×10^{-6}		10^{-6}
1 m^2 =	1.550	10.764	1.196	10^6	

Force

	Newton (N)	kilopond (kp)	pound force
1 Newton (N) =		0.10197	0.22481
1 kilopond (kp) =	9.80665		2.20463
1 pound force =	4.4482	0.45359	

Volume

	inch^3	US quart	imp. gallon	foot^3	US gallon	liter
1 inch^3 =		0.0173	0.0036	0.00058	0.0043	0.0164
1 US quart =	57.75		0.2082	0.0334	0.25	0.9464
1 imp. gallon =	277	4.8		0.1604	1.2	4.546
1 foot^3 =	1.728	29.922	6.23		7.48	28.317
1 US gallon =	231	4	0.8327	0.1337		3.785
1 liter =	61.024	1.0567	0.220	0.0353	0.264	

Velocity (Speed)

	foot/s	foot/min	mile/hour	metre/s	km/hour
1 foot/s =		60	0.6818	0.3048	1.097
1 foot/min =	0.017		0.0114	0.00508	0.01829
1 mile/hour =	1.4667	88		0.447	1.609
1 metre/s =	3.280	196.848	2.237		3.6
1 km/hour =	0.9113	54.68	0.6214	0.278	

Mass

	ounce	pound	kg
1 ounce =		0.0625	0.0283
1 pound =	16		0.4536
1 kg =	35.274	2.2046	

Pressure

	inch Hg	psi	atmosphere	torr	mm Hg	bar	MPa	kg/cm^2
1 inch Hg =		0.491	0.0334	25.4	25.4	0.0339	0.00339	0.0345
1 psi =	2.036		0.0680	51.715	51.715	0.0689	0.00689	0.0703
1 atmosphere =	29.921	14.696		760	760	1.0133	0.10133	1.0332
1 torr =	0.0394	0.0193	0.0013		1	0.0013	0.00013	0.00136
1 mm Hg =	0.0394	0.0193	0.0013	1		0.0013	0.00013	0.00136
1 bar =	29.53	14.504	0.987	749.87	749.87		0.1	1.020
1 MPa =	295.3	145.04	9.869	7498.7	7498.7	10		10.2
1 kg/cm^2 =	28.950	14.22	0.968	735.35	735.35	0.980	0.098	

For your Notes

Technical Questionnaire

Technical Questionnaire

We would be pleased to send you a technical proposal/quotation to your sealing or bearing application upon receipt of this questionnaire. (Look for address and fax number on the back page of the catalogue).

Name:	Date:
Division:	
Company:	❑ Technical proposal:
Type of industry:	❑ Quotation for pieces
Address:	Annual usage:
Postal Code:	
Telephone:	❑ Others:
Telefax:	

Please draw the relevant components here, providing dimensions and machining tolerances, or send a copy of your hardware drawing. Also indicate any dimension that can be changed.

Service Conditions and Hardware:

Type of component:		Short description of your application or objectives:
Pressure range:		
Operating pressure:		
Temperature range:		
Operating temperature:		
Speed max:	Operating speed:	
Media:		
Movement:		
❑ oscillatory	❑ reciprocating	
❑ rotation	❑ static	
Number of cycles/frequency:		
Maximum stroke:		
Material (housing/countersurface):		
Surface finish:		
Service life required:		

For your Notes